INFLUENCE OF PROVIDER ADVICE AND MATERNAL ATTITUDES ON WEIGHT CHANGE AND PHYSICAL ACTIVITY DURING PREGNANCY AND POSTPARTUM

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ABSTRACT

RENÉE M. FERRARI: Influence of Provider Advice and Maternal Attitudes on Weight Change and Physical Activity during Pregnancy and Postpartum
(Under the direction of Drs. Anna Maria Siega-Riz and Cathy Melvin)

Overweight and obesity are becoming the norm for American women. The 1999-2002 National Health and Nutrition Examination Survey found that greater than half of women ages 20-39 are overweight (25%) or obese (29%), representing a dramatic increase in prevalence over the past several decades. Not surprisingly, Healthy People 2010 has designated a reduction in overweight and obesity as one of the ten Leading Health Indicators for women. Both gaining too much weight during pregnancy and the failure to lose that weight are believed to pose risks for continued overweight/obesity over the course of a woman's lifetime. Unfortunately, we know little about why women gain too much pregnancy weight and why they fail to lose it during the postpartum period.

Using data from a longitudinal cohort study that followed women from pregnancy to one year postpartum, this dissertation explored possible influences on pregnancy weight gain and postpartum weight retention. Two papers focused on pregnancy: the first examined the association between maternal attitudes about pregnancy weight gain and gestational weight gain adequacy, while the second explored whether provider advice in pregnancy is associated with adequacy. The third paper focus on the postpartum period and aimed both to characterize postpartum provider advice about weight loss and physical activity and to examine the association of such advice with weight retention and physical activity levels at 3 months postpartum.

Results suggest that weight gain and postpartum weight retention are intransigent problems that show little change by attitude or advice; that measurement of attitudes and

advice needs to be improved if we are to better understand their influence on weight gain and weight retention; that women are not receiving or not hearing provider advice; and that advice alone may not be enough to help women gain a healthy pregnancy weight and lose that weight in a timely fashion. This dissertation contributes to the body of knowledge about pregnancy weight gain and postpartum weight retention and holds implications for future interventions aimed at lowering excessive gestational weight gain, postpartum weight retention, and rates of overweight and obesity in reproductive-aged women.

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Gratitude is the fairest blossom which springs from the soul.
~Henry Ward Beecher

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LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
ARR	Adjusted Risk Ratio
BMI	Body Mass Index
CDC	Centers for Disease Control
IOM	Institute of Medicine
MET	Metabolic Equivalent
PIN	Pregnancy, Infection, and Nutrition Study
PIN 3	Pregnancy, Infection, and Nutrition Study, phase 3
PinPost	Pregnancy, Infection, and Nutrition Postpartum Study
PWGAS	Pregnancy Weight Gain Attitude Scale
RR	Risk Ratio
UNC	The University of North Carolina at Chapel Hill

CHAPTER 1

INTRODUCTION

Overweight and obesity rates among reproductive-aged women are rising dramatically.(1) The 1999-2002 National Health and Nutrition Examination Survey found that greater than half of women ages 20-39 are overweight (25%) or obese (29%), representing a dramatic increase in prevalence over the past several decades.(2) Not surprisingly, Healthy People 2010 has designated a reduction in overweight and obesity as one of the ten Leading Health Indicators for women.(3)

This dissertation is focused on two contributors to overweight/obesity among reproductive-aged women: excessive pregnancy weight gain and postpartum weight retention. Gaining too much weight during pregnancy has been linked to long-term female overweight and obesity.(4, 5) Unfortunately, over half of women giving birth every year gain above medical recommendations.(6-8) Likewise, postpartum weight retention is believed to be an important contributor to the epidemic levels of overweight and obesity(2) among reproductive-aged women.(9-12) Though average weight retention at 1 year postpartum is minimal, the range of weight retention is highly variable and some sub-populations of women retain an excessive amount of pregnancy weight.(13)

Potential influences on weight gain and postpartum retention include attitude toward weight gain, physical activity, and provider advice. Earlier studies have identified a link between attitude and weight gain, such that women with a negative attitude were more likely to gain inadequately during pregnancy (14) or excessively (15). However, not all studies found such an association(16, 17), suggesting a need for continued

investigation. In addition, no studies were found that examined the potential link between provider advice and maternal attitudes.

Remarkably, little is know about the role of provider advice in pregnancy weight gain. Only four earlier studies were uncovered that examined the role of provider advice during pregnancy and three of those were conducted prior to or very soon after the most recent medical weight gain guidelines were made public, nearly twenty years ago.(18-21) And, although health care providers are potentially important sources of information about healthy weight loss and physical activity in the postpartum period, no published observational studies were identified that examined the role of provider advice on postpartum weight loss or physical activity.

I had three specific aims for this dissertation:

1) examine the association between maternal attitudes about pregnancy weight gain and pregnancy weight gain adequacy;
2) examine the association between provider advice about pregnancy weight gain and pregnancy weight gain adequacy; and
3) examine the association between postpartum provider advice and weight loss and physical activity postpartum.

Both maternal attitudes about pregnancy weight gain and provider advice are potentially modifiable. As such, they may be targets for future interventions aimed at lowering excessive gestational weight gain, postpartum weight retention, and rates of overweight and obesity in reproductive-aged women.

The dissertation is divided into 3 papers. The first explores maternal attitudes about weight gain and actual gain. The second explores provider advice during pregnancy, seeking to understand the association between weight gain advice and actual weight gain. Finally, the third paper examines provider advice in the postpartum period, exploring the

association between weight loss advice and weight retention, and physical activity advice and physical activity levels in a North Carolina sample of women at 3 months postpartum.

Background

Obesity among reproductive-aged women

Obesity is steadily on the rise in developed countries.(22) The World Health Organization defines obesity as “abnormal or excessive fat accumulation in adipose tissue, to the extent that health is impaired.”(23) Obesity is associated with health problems such as diabetes, heart disease, and osteoarthritis, as well as social discrimination.(24, 25)

In accordance with the rise in the general population, rates of overweight and obesity in women of reproductive age are rising dramatically.(1, 26) Longitudinal data from the National Health Examination Survey and the National Health and Nutrition Examination surveys indicate that rates of overweight have increased from 10.1% in 1960 to 20.2% in 1991 in women aged 20-29, and from 21.9% in 1960 to 34.9% in 1991 in women aged 30-39.(25) Another national study found that obesity prevalence increased 69.9% among 18-29 year old women (from 7.1%-12.1%) and increased 49.5% among women aged 30-39 (from 11.3% to 16.9%) between the years 1991 and 1998.(26) Rates of overweight for Black women continue to be markedly high compared to white women, estimated to be 71% vs. 49%, respectively in 1999-2000.(27) Not surprisingly, Healthy People 2010 has designated a reduction in overweight and obesity as one the ten Leading Health Indicators for women.(3)

Beginning pregnancy obese, defined by the IOM Subcommittee as a Body Mass Index (BMI) >29 kg/m(28) predisposes women to significant health risks during pregnancy. Researchers have found that obese women are more likely than non-obese women to have pregnancy complications such as pregnancy induced hypertension, gestational diabetes, cesarean section, and maternal morbidity,(29) as well as prolonged labor and back pain.(30)

Additional studies report that infants born to obese women are at greater risk for macrosomia (being born oversized) and perinatal death than those born to normal weight women.(29)

Pregnancy weight gain

Weight gain or loss in the non-pregnant state is the net result of the difference between energy from dietary intake and energy expenditure through physical and metabolic activity. During pregnancy, extra energy is needed to support both fetal development and the increased metabolic needs of maternal bodily processes, including tissue synthesis as well as the work of the cardiovascular, renal, and respiratory systems.(31) In the absence of complications such as edema, average maternal weight gain can be specifically attributed to the fetus (25%), the placenta (5%), amniotic fluid (6%), extra cellular fluid (13%), and blood volume (10%), with the remaining 41% accounted for in breast and uterine growth, and maternal fat stores.(32)

The amount of weight gained in a pregnancy varies by time period, with relatively little weight gained in the first 10 weeks. Energy requirements are greatest between weeks 10 and 30, during which time most of the fat is deposited.(32) Energy demands taper off in the latter stages of the pregnancy, usually weeks 36 to 40.(32) Throughout pregnancy, even with a decrease in physical activity, there is still a net increase in required calories.(32) To meet the increased energy demands of gestation, women are advised to consume approximately 2200 kcal a day throughout the pregnancy, increasing dietary intake by 300 extra kcal a day in the second and third trimesters.(32)

During the latter half of the 20th century, the American medical community's position on maternal weight gain evolved considerably. Throughout this period, a number of official entities published weight gain recommendations. In the 1940s and 1950s, unlike many other industrialized nations, physicians in the United States were strongly advising pregnant

women to limit weight gain to less than 9 kg (about 20 lbs), with the belief that low gain would decrease delivery complications, most importantly eclampsia and pre-eclampsia (a serious, potentially fatal maternal health condition characterized in part by hypertension).(33) By the late 1960s there was substantial evidence linking low weight gain to low infant birth weight and attending problems, resulting in a liberalization of guidelines.(28) In 1970 the National Academy of Sciences recommended an average gain of 11kg (about 24 lbs) within a range of approximately 9 to 12 kg (approximately 20-26 lbs).(28) By 1978, in a joint recommendation by the American College of Obstetrics and Gynecology and the American Dietetic Association, that range had expanded to 9 to 13.6kg (20-30 lbs).(28)

In 1990, the Institute of Medicine's (IOM) subcommittee on Nutritional Status and Weight Gain During Pregnancy developed new weight gain recommendations.(28) Recognizing that weight alone is a limited measure of health status, the Institute of Medicine based their recommendations on body mass index (BMI), an expression of the relationship between a person's weight and height.(28) BMI is calculated as weight in kilograms divided by height in meters squared.

Not only do these most recent recommendations establish new weight gain guidelines, but more significantly, for the first time they are explicitly related to a woman's pregravid weight.(28) The guidelines reflect consistent findings that pre-pregnancy weight affects infant birth weight outcomes independent of gestational weight gain. The subcommittee further acknowledged the need for even obese women to gain some weight with pregnancy, commensurate with the amount of weight that would be accounted for by the products of conception. However, they refrained from making a recommendation about an upper limit for weight gain for obese women, citing a lack of research on the topic and calling for further studies.(28)

Researchers have studied the effects of pregravid weight and gestational weight gains on birth outcomes, but have failed to give the same attention to their effects on women's health outcomes.(11, 28) The limited literature on the effects of pregravid weight and pregnancy weight gain on women's health is evidence of the need to turn attention more fully to this relationship. Fortunately, the focus of research on pregravid weight and gestational weight gain has expanded to include the health of the mother, with particular attention paid to the effects of postpartum weight retention.

Postpartum Weight Retention

Postpartum weight retention may be an important contributor to the epidemic levels of overweight and obesity(2) among reproductive-aged women.(9-12) Weight retention is defined as the difference between a woman's postpartum and pre-pregnancy weight.(28) Though average weight retention at 1 year postpartum is minimal, the range of weight retention is highly variable and some sub-populations of women retain an excessive amount of pregnancy weight.(13) Gunderson et al reported mean ranges of weight retention from an index pregnancy to a subsequent pregnancy of -3.5-10.0 kg (-7.7-22.0 lbs) for the lowest quartile of weight gain to 3.0-22.0 kg (6.6 – 48.5 lbs) for the highest quartile.(4) A study of 1,423 women found average weight retention at 1 year follow-up was only 0.5 kg (1.1 lb), but ranged widely, from -12.0 to 26.0 kg (-26.5-57.3 lbs).(10) Further, fourteen percent of the study population had retained >5.0 kg (11 lbs). Olson et al followed 540 women through 1 year postpartum and found that 25% retained 4.55 kg (10.0 lbs) or greater.(34) Such findings suggest that a sizeable proportion of postpartum women are at risk for excessive postpartum weight retention.

Excessive pregnancy weight gain is the primary predictor of postpartum weight retention.(6, 35-38) Research suggests that at some point gestational weight gain ceases to benefit the fetus and instead poses health risks for the mother.(6, 37) A study by Lawrence

et al found that women who gained more fat did not give birth to heavier babies but rather retained that weight as maternal fat stores.(39) Similarly, a study by Scholl et al found that an excessive rate of weight gain by women within a normal BMI range did not promote infant outcomes but rather increased overweight status among women after birth.(36) The effects of excessive weight gain on postpartum weight retention have been documented as far as one year after birth,(37) and some research has shown different patterns of weight retention according to race.(6) For example, White women who gained more than the recommended amount substantially increased their chances of retaining nine or more pounds (four kilograms) compared with those who gained less, while Black women with excessive gains were even more likely to retain that weight than White women in corresponding weight for height ranges.(6) Other postulated influences on postpartum weight retention include low socio-economic status, parity, and high pre-pregnancy BMI.(38)

Physical activity during pregnancy and weight change

Physical activity during pregnancy is believed safe for most women and is recommended by the American College of Obstetricians and Gynecologists.(40) The official recommendation states that, “in the absence of either medical or obstetric complications, 30 minutes or more a day on most, if not all, days of the week is recommended for pregnant women.” Exercise in pregnancy is believed to impart the same benefits as exercise before pregnancy(40) and may have the added benefit of preventing gestational diabetes(41) or ameliorating its effects.(42) Common recreational activities engaged in by pregnant women include walking, swimming, gardening, weight lifting, and aerobics.(43)

Although the physiology of weight gain with regard to energy intake is well-understood, there is little research in the area of the effect of physical activity during pregnancy on pregnancy weight gain.(44) An extensive literature search uncovered five studies in the field conducted in the last 15 years. Three of those studies showed no

association between physical activity and gestational weight gain.(45-47) In one study, over 800 pregnant women were interviewed twice during pregnancy about physical activity.(46) The authors found no difference between exercisers vs. non-exercisers with regard to pregnancy weight gain. A prospective study of nearly 400 women assessed physical activity at two time points during pregnancy using a questionnaire.(45) Activity was categorized into four levels based on duration and intensity. Level of exercise was unrelated to gestational weight gain when compared with sedentary controls.

Two studies did find an effect of exercise on weight gain.(17, 48) Clapp et. al. found that exercise during pregnancy significantly reduced fat deposition and gestational weight gain in late pregnancy but not in early pregnancy.(48) There was decreased overall gain in the exercising group compared to controls (13.0 +-0.5 kg vs. 16.3 +-0.7 kg, respectively) but the total gain for exercisers was still within recommended limits. In a prospective study of over 600 women, Olson and Strawderman found a significant association between activity and weight gain: physically active women gained less weight overall than sedentary women.(17) Both studies assessed activity levels with a questionnaire and used clinical records for weight measurements.

It is not clear why most studies have not found an effect of physical activity on weight gain, given our understanding of the association between energy intake and expenditure. One possibility is that weight gain in pregnancy is more strongly determined by fetal requirements and less so by maternal physical activity, at least during early pregnancy.(48) It is also likely that measurement error of the exposure and the outcome play a significant role (i.e. methodological flaws in assessing activity and flaws in measuring weight gain). An additional explanation is that confounding by unknown or uncontrolled-for variables, such as dietary intake, are masking the association between activity and weight gain.(49) The conflicting results suggest need for improved measurement of physical activity and the need to account for other factors that might be clouding its association with weight gain.

Physical activity postpartum

The 2002 ACOG guidelines for exercise during pregnancy and the postpartum period state that, “Many of the physiologic and morphologic changes of pregnancy persist at 4 – 6 weeks postpartum. Thus pre-pregnancy exercise routines may be resumed gradually as soon as it is physically and medically safe… This will vary from one individual to another…No known maternal complications are associated with resumption of training.”(43) ACOG addresses the safety of exercising while nursing and the benefit of exercise in reducing the risk of postpartum depression, but does not mention the role of physical activity in weight loss.

Studies of the benefits of physical activity for postpartum weight loss have yielded inconclusive results. A handful of studies found that physical activity postpartum aids women in returning to their pre-pregnancy weight and reducing overall weight retention.(50-52) (53, 54) The Stockholm Pregnancy and Weight Development Study followed 1432 women from pregnancy through one year postpartum and found that women who engaged in regular recreational physical activity were more likely to return to their pre-pregnancy weight than women who exercised less often or not at all.(54)

Similarly, a study of vigorous activity postpartum among 1,003 healthy women found an association between activity and weight loss at six weeks postpartum. Participants completed a questionnaire at six weeks postpartum and their weight was recorded at the clinical visit.(52) Women with high levels of vigorous activity retained less weight than those with lower levels of activity. Another study surveyed 74 British women at two and a half years postpartum.(53) Those who failed to resume their usual physical activity were significantly more likely to retain their pregnancy weight than their more active counterparts.

In contrast, other studies did not demonstrate such an association.(55-57) In a study of 795 White, middle-class women, researchers examined factors associated with postpartum weight loss. Women were followed for six months postpartum and surveyed

about social and health behaviors, including exercise. The authors found no association between self-reported physical activity levels and subsequent weight loss measured at a 6ix-month postpartum clinic visit.(55) Two other studies revealed no overall association between physical activity and returning to pre-pregnancy weight, but did find an association among a particular sub-group.(56) Boardley et al found higher weight retention among Black women compared to White women, a difference attributed to the higher physical activity levels among the latter group.(56) Walker and Freeland-Graves reported less postpartum weight retention with increased aerobic activity levels in formula-feeding but not breastfeeding women.(57)

Determinants of physical activity in the postpartum period are not well studied. Working greater than 45 hours/week during pregnancy, already having a child in the home, and reporting that lack of childcare was a barrier to activity were all found to predict low physical activity postpartum.(58) Other studies found high self efficacy(59, 60) and being in the action and maintenance stages of change(60) [based on the Stages of Change theory(61)] predicted high activity postpartum, while another found high levels of activity among women who adapted well to the postpartum period and who participated in physical activities defined as “fun”, including exercising socially and engaging in hobbies.(52)

In a review of literature on physical activity postpartum, Larson-Meyer identified several problems shared by the research. Some of the limitations include retrospective data based on self-report; poor accounting for socio-economic factors; lack of consideration of feeding method (most studies are of breastfeeding women); and, importantly, poor definitions and measurement of physical activity.(50) The author further concludes that physical activity alone may not be enough for postpartum weight loss but could be an effective means of weight loss when coupled with a calorie-restrictive diet. The proposed study will address some of these gaps, notably by using a reliable questionnaire administered during pregnancy (with a short recall period of 7 days prior to interview) that

spans multiple types of physical activity (rather than being limited to recreational activity). Additionally, the study will include both formula and breast-feeding women, increasing generalizability compared to other studies.

Maternal attitudes: pregnancy weight gain

In 1985, Palmer, Jennings, and Massey developed a scale to assess pregnant women's attitudes toward pregnancy weight gain.(14) Attitude can be defined as "a predisposition to classify objects and events and to react to them with some degree of evaluative consistency…(attitudes)…are manifested in conscious experience, verbal reports, gross behaviour, and physiological symptoms."(62) The researchers developed 40 statements reflecting plausible attitudes of women about pregnancy weight gain, which they pared down to 18 after review by an external panel of judges (including pregnant women and mothers) and after testing for item discrimination. Items that did not differentiate between a positive and a negative attitude were dropped (the authors do not define what they mean by positive or negative attitude) and tested for reliability using the Spearman Brown Prophecy Formula. They field tested the scale on a childbirth class of 29 white, middle-class women with a greater than high school level of education, and found a statistically significant association ($p<0.025$) between attitude (whether positive or negative) as measured by the scale and actual weight gain.(14)

Several other researchers have used Palmer, Jennings, and Massey's Pregnancy Weight Gain Attitude Scale. Most,(15, 16, 63-65) though not all,(17) have found attitudes to be associated with actual weight gain. Stevens-Simon, Nakashima, and Andrews found that a greater proportion of the 99 adolescents with high pre-pregnancy weights had a negative attitude about weight gain than their lower- weight adolescent counterparts, but this association was not statistically significant.(65) They found also that the rate of weight gain was correlated with 4 questionnaire items, but not the composite score, and concluded that

a negative attitude toward weight gain could adversely affect pregnancy weight gain among adolescents, presumably by limiting weight gain and increasing the risk for low birth weigh infants.

Similarly, Copper and colleagues conducted a prospective study of 1000 predominantly black, low-income women and found that the attitude score overall was not related to pregnancy weight gain but that normal weight and overweight/obese women had more negative attitudes toward pregnancy weight gain than underweight women, and also were less likely to follow provider recommendations.(16) In a convenience sample of 46 pregnant adolescents, Gutierrez found that none of the adolescents gained in excess of IOM recommendations, but those with a negative weight gain attitude gained significantly more than those with a positive attitude (38.97 +-8.9 vs. 30.75 +- 8.13, $p<0.05$).(63)

DiPietro, Millet, Costigan and colleagues examined psychosocial measures and their effect on weight gain attitude and behaviors.(15) Using factor analysis of the Pregnancy, Weight Gain and Attitude Scale, they demonstrated four factors to be associated with actual gain: positive pregnancy body image, negative pregnancy body image, indifference toward weight gain, and weight gain restrictive behaviors. Factor scores did not vary by race and there was no association between pregravid BMI and questions and factors. Women who gained excessively were statistically more likely to agree or strongly agree with negative body image statements than women who gained within or less than the recommendations.

A second factor analysis by authors Kendall, Olson, and Frongillo found positive and "healthy" factors, but did not indicate which questions corresponded to which factor.(64) They found a Cronbach's alpha of 0.8 and 0.65 for factor 1 (negative) and factor 2 (healthy) respectively and also found a strong, inverse association between BMI in the first 3 months of pregnancy and attitude. In contrast to the above studies, a prospective study of 622 mainly white, rural-dwelling women did not find that maternal weight gain attitude was

strongly related to weight gain.(17) The authors do not offer an explanation for the lack of association.

Finally, Wiles conducted a qualitative study of 37 overweight, white women from one urban and one rural hospital in England.(66) She interviewed the women twice, once between 30 and 40 weeks gestation and again at 6 weeks postpartum. The women voiced concerns about returning to their pre-pregnancy weight as well as concerns for fetal health. They reported that they had received inadequate provider advice, and, in the absence of advice, made their own determinations about appropriate weight gain. Importantly, Wiles found that the women did not believe information about appropriate weight gain was relevant to them (as overweight women) and concludes that materials may need to be developed specifically targeted to women beginning pregnancy overweight and obese.

The inconclusive results regarding maternal weight gain attitude and its influence on actual gain suggest a need for continued study, including an exploration of how maternal attitude might interact with other factors. To date no published studies have explored the relationship between provider advice and maternal attitude, nor have any examined how the two together might affect women's pregnancy weight gain.

Provider advice

Perhaps one of the more fundamental duties of the health care provider is to advise his or her patients about how to take care of their health. Research suggests that many patients follow the advice they receive from their providers. (67-69) Whether the objective is to get a mammogram, lose weight, or become more active, patients who are advised by their providers to engage in healthy behaviors do so at a greater rate than patients who do not receive such advice.

Researchers studying smoking cessation found that patients advised to quit smoking by their health care providers were significantly more likely to do so than patients who were

not advised.(70, 71) Overweight persons advised to lose weight by their providers were more than twice as likely to attempt to lose weight than unadvised persons.(68) More than 50% of participants in a physical activity intervention became physically active following provider advice compared to only 12% of their respective controls.(69) Finally, in a study of women's use of mammography, researchers found that women who reported being advised to get a mammogram were far more likely to do so than women not reporting such advice (adjusted OR=16.11, 95% CI=12.37, 21.00).(67) Clearly, provider advice plays an important role in encouraging patients to engage in healthy behaviors.

Provider advice about pregnancy weight gain

Similarly, researchers have found that pregnant women who report being advised about the appropriate amount of weight to gain during pregnancy are more likely to gain within the recommended range than are women who do not report receiving such advice.(18-20) At least four studies have assessed the influence of provider advice about gestational weight gain on actual or target gain.

Taffell and Keppel analyzed data from the 1980 National Natality Survey.(72) At the time of the survey, practice guidelines stipulated that pregnant women ought to gain between 22 and 27 lbs (10 -12 kg).(73)The advice questions on the survey asked women to report if their doctor had advised a weight gain limit, and if so, the limit amount. Of the 7,704 women who reported receiving prenatal care, 39% reported receiving no advice about a weight gain limit from their doctor. Sixty-one percent reported receiving advice and, of those, about one quarter reported being advised to gain less than 22 lbs, nearly half reported an advised limit of 22 to 27 lbs, and the remaining quarter reported being advised to gain 28 lbs (12.7 kg) or more. Women who reported being advised to limit gain to less than 22 lbs were significantly more likely to have inadequate weight gain than women who were advised to

gain at least 22 lbs; in fact, the lower the reported advised limit, the greater the likelihood of gaining less than the obstetric recommendations of at least 22 lbs.

Taffell, Keppel, and Jones conducted a similar study using data from the 1988 National Maternal and Infant Health Survey.(20) This survey asked women about weight gain advice, amount advised, and total gain. The obstetric recommendation of gains between 22 and 27 lbs was still in effect in 1988.(73) The authors found that 27% of women reported receiving no advice. Importantly, 70% of women who reported being advised to gain within the recommended range did so.

In a third study, researchers analyzed data from a mail survey of 2,237 predominantly white, middle-class women.(18) The women in the study gave birth in the spring and fall of 1993, three years after the IOM weight gain recommendations and one year after the American Academy of Pediatrics and the American College of Obstetricians and Gynecologists adopted the recommendations.(74) Researchers asked women to report if they received advice about weight gain and to report their total pregnancy weight gain. Nearly one-third (27%) of women reported receiving no advice. Among women who reported receiving advice, 14% reported being advised to gain less than the IOM recommended amount and 22% reported being advised to gain more than recommended. Of the 1,661 women with data about actual weight gain, those who reported having received advice from their provider about the appropriate amount of weight to gain during their pregnancy were more likely to gain within the appropriate range than women who reported that they were not so advised.

Finally, Stotland and colleagues examined the association between provider advice and women's target pregnancy weight gain.(21) In a cohort of 1,198 pregnant women, 33.1% reported receiving no advice from a provider about how much weight to gain in pregnancy. The authors found that lack of advice was associated with weight gain both below and above the IOM guidelines.

The collective findings suggest that provider advice does indeed influence women's pregnancy weight gain. However, the studies all suffered from poor outcome measurement, using only maternal self-report rather than clinical measurements for pregnancy weight gain. The two early studies also had limited sampling frames: the first was limited to married pregnant women and both mainly comprised White women. Importantly, though providers other than clinicians frequently provide advice, none of the studies differentiated between type of provider offering advice, and the first in fact only asked specifically about physician advice. Finally, with the exception (which was conducted recently but focused on target, rather than actual, gain) the studies are outdated. Of the three studies on actual weight gain, the first two were based on pre-IOM guidelines, which did not account for pregravid BMI, and the latest examined data from 1992-1993, only three years after the IOM recommendations were made public and a single year after the American Academy of Pediatrics and the American College of Obstetricians adopted the recommendations.(18-20)

Provider advice about postpartum weight loss

Evidence from other areas of study suggests that many patients do follow the advice they receive from their providers, though this has yet to be examined in a postpartum population. Not a single published study was found that addressed advice to women about postpartum weight loss.

Provider advice about postpartum physical activity

Physical activity advice for postpartum women is poorly studied. A literature search uncovered no studies that addressed the topic in the postpartum period. There was, however, one study that examined advice and physical activity during pregnancy(75) which may serve as a point of reference for postpartum advice.

Clarke and Gross examined women's information sources about physical activity during pregnancy.(75) The authors surveyed 57 pregnant women in the United Kingdom, using open-ended questions about sources of physical activity advice during pregnancy. At four points during their pregnancy (16, 25, 34, and 38 weeks gestation), women were asked if they had received advice about physical activity in the four weeks prior to the interview. Although many women indicated receiving advice, few reported receiving such advice from health care providers.

At 16 weeks gestation, 11 of the 57 women reported receiving no advice, and of the 46 who did report having received advice, only ten reported advice from health care providers (others reported advice from media or family and friends). At 25 weeks gestation, 20 women reported receiving no advice and of the remaining 37, merely five reported advice from providers. The number of women reporting no advice at 34 weeks gestation increased to 26, with only six reporting advice from providers. Finally, of the 51 women interviewed at week 38, nearly half (24) reported receiving no advice; of those who did report receiving advice, nine reported advice from health care providers. The authors also found many reports of confusing or conflicting advice and conclude that prenatal health education is doing a poor job of educating pregnant women about physical activity.(75)

Intervention studies to reduce excessive pregnancy weight gain and postpartum weight retention

The strong association between pregnancy weight gain and weight retention postpartum suggests the importance of primary prevention of excessive weight gain during pregnancy.(55, 76) However, a handful of intervention studies aimed at preventing excessive gain have yielded conflicting results.(76-78) One such intervention included 179 intervention women and 381 historical controls (drawn from same population, but who had received their prenatal care three to five years prior).(78) The study included only women

with a pregravid normal and overweight BMI and the two study groups were similar across the measured variables believed to be important in pregnancy weight gain. The intervention included: clinical guidance using an amended weight gain chart developed by the researchers; regular weight monitoring; a booklet addressing weight gain and diet; and 5 newsletters with motivating messages about pregnancy weight gain. Overall, weight gain did not differ between the two groups. However, weight gain was statistically significantly lower for low-income women. Importantly, these women retained less weight postpartum than their higher income counterparts as well.

Another intervention study found similar results. A randomized controlled trial compared a behavioral intervention with usual care among of 110 women (57 intervention, 53 control).(76) The intervention and control groups included normal weight and overweight women, and did not differ on measured demographic characteristics. The intervention included written and oral guidance about healthy weight gain, newsletters, and personalized weight gain information after each prenatal visit. Women who gained in excess of recommendations for that visit received behavioral goals after the visit, that focused on reducing fat intake and making healthy choices, followed by meal plans and calorie goals for women who continued to gain weight excessively. The women also received advice to increase physical activity, especially walking. As in the previous study, only the low-income women (specifically, the low-income overweight women) had significantly lower weight gain than others.

A third intervention targeted to Cree women (n=112 cases and 107 controls) included individualized diet and exercise counseling once in late pregnancy and once at 6 weeks postpartum.(77) Gestational weight gains did not differ between the two groups, though dietary intake among both groups was correlated directly with weight gain. Interestingly, the authors identify maternal beliefs and attitudes about pregnancy weight gain and physical activity as likely contributors to the lack of intervention effect. Discussions with

women in the Cree community revealed that, among other attitudes, being plump during pregnancy is desirable and at the same time prenatal physical activity is not valued.

In contrast to interventions during pregnancy, interventions targeting the postpartum period have shown more promising results.(79-81) A study of 40 overweight, postpartum (6weeks to 6 months) women randomized 19 women to a structured intervention that included individualized diet and physical activity information and advice, as well as weekly meetings and food/activity diaries.(79) The 21 control women received a self-directed intervention comprising a one-hour long generalized session about diet and physical activity. At one year postpartum, among the 23 participants remaining, the intervention group had significantly greater weight loss compared with the control women (n=13 women vs. 10, respectively, at one year postpartum).

A second study found similar results. Ninety women who were 3-12 months postpartum and had weight retention of at least 15 lbs (6.8 kg) above their pregravid weight were randomized to receive either a 6-month correspondence intervention (n=47) or no treatment at all (n=43).(80) The behavioral intervention focused on deceasing fat and calorie intake and increasing physical activity, and consisted of two group sessions, correspondence materials, and weekly or biweekly telephone contact that touched on progress and problem-solving. The treatment group was significantly older and more likely to be married than the control group, but did not differ on other baseline characteristics. After attrition, the intervention group (n=36) lost significantly more weight (p=0.03) and a significantly greater proportion returned to their pre-pregnancy weight (p=0.01) than controls (n=26).

Kinnunen et al conducted an intervention to reduce postpartum weight retention among 92 women in six different health care centers in Finland.(81) The 48 women in the intervention group received intensive nutritional and physical activity counseling through repeated clinic visits from 2-10 months postpartum; participation rates in the counseling

sessions was ≥90%. Controls (n=37) received usual care, reported to be approximately 4 minutes of provider advice for both diet and physical activity. The authors refer to the usual care as 'advice' rather than counseling. At the conclusion of 10 months postpartum, there were no differences in average weight retention but a higher proportion of the intervention group had returned to their pre-pregnancy weight (50%, n=23) compared to the control group (30%, n=26) (p=0.06). The adjusted odds of achieving pre-pregnancy weight was 3.89 (95% CI 1.16, 13.04) for the intervention group compared to controls. The authors highlight the need for larger trials to confirm their findings.

Dissertation Methods

The purpose of this dissertation was to examine the role of maternal attitudes and provider advice on gestational weight gain, postpartum weight retention and physical activity during pregnancy and postpartum. Of particular interest was the relationship between provider advice and actual behavior. Drawing from a sample of 2,006 pregnant and postpartum women enrolled in the Pregnancy, Infection and Nutrition Study (PIN), I used generalized multinomial logistic, log-linear, or linear regression, as appropriate, to answer the questions under examination. Details about the study design and analysis are described below.

Study Design and Sample

Data for this dissertation come from the Pregnancy, Infection, and Nutrition Study, located at the Carolina Population Center at the University of North Carolina at Chapel Hill (UNC). The PIN Study is a longitudinal, prospective cohort study of risk factors for preterm birth. The dissertation is a secondary data analysis using data from PIN 3 (the third phase of the PIN study) and PinPost (the postpartum component of the PIN study). The Institutional Review Board of the University of North Carolina at Chapel Hill approved all study protocols.

PIN 3. PIN 3 recruited women from public and private prenatal care clinics at the University of North Carolina (UNC) Hospitals. Eligible women included English-speaking women less than 20 weeks' gestation who were at least 16 years old, had a singleton fetus, planned to continue care at the clinic, and had access to a telephone for interviews. Study staff identified potential PIN 3 subjects by reviewing medical charts of new prenatal patients. To track study participants, staff entered relevant demographic and pregnancy related data from the prenatal record into a computerized database. Women were recruited at their second prenatal visit if they were less than or equal to 20 weeks' gestation. Data on socio-demographics, medical history, current pregnancy, and health behaviors were collected via clinic visits, in-depth phone interviews, and self-administered questionnaires. Between January 2001and June 2005, a total of 2,006 women participated in PIN 3. Details on the PIN study can be found at http://www.cpc.unc.edu/projects/pin.

PinPost. PinPost is a longitudinal cohort study that followed women through 1 year postpartum and aimed to investigate factors related to weight loss in the postpartum period. PinPost participants are a subset of the women enrolled in PIN 3; thus the sample is derived from the 2,006 women recruited into PIN between January 2001 and June 2005. Women eligible for PINPost included those enrolled in PIN who delivered live-born infants between October 2002 and December 2005 and who lived in the study's catchment area (required to conduct in-home visits), n=1,169. Women were approached while still pregnant and asked if they would agree to being contacted postpartum about another research study. One hundred and eighty-seven women (16%) declined participation and 294 (25.1%) were unreachable or ineligible due to medical constraints. The remaining 688 (58.9%) agreed to participate and completed three-month home interview.

PINPost staff visited study participants in their homes at three months postpartum between April, 2003 and March, 2006. Visits lasted approximately 60-90 minutes and included measurement of women's height using a standing height rod; measurement of

weight and percent body fat using a Tanita bioelectric impedance scale validated for use in an adult population;(82) and an extensive interview covering socio-demographics, diet, physical activity, infant feeding, body image, health behaviors, psychosocial factors, and provider advice; and a food frequency questionnaire that assessed dietary intake in the three months prior to the home visit.

Data Collection Procedures

A variety of data is collected for PIN 3 and PinPost, including demographics, biological specimens, psychosocial information, and physical measurements. Table 1.2 details the data collection procedures for both PIN 3 and PinPost. Though Table 1.2 lists all study protocols, this study will use demographic information, selected data from the PIN 3 first and second phone interviews, and the PinPost 3-month home visit only (relevant information is shaded). Quality control measures were put in place to ensure data validity. Specifically, each month one phone interview 1 and one phone interview 2 per interviewer was recorded and then reviewed by the interview coordinator and the study coordinator. Interviewers also use a Question by Question document, which details how the interviewer should handle various response possibilities not already described in the interview form.

Ascertainment of the outcomes

Adequacy of Gestational Weight Gain. Adequacy of gestational weight gain was defined as gaining within predetermined ranges of the 1990 Institute of Medicine (IOM) guidelines. Self-reported pregravid weight and height measurements were collected at the time of recruitment and used to calculate pregravid BMI. Women were categorized into BMI categories based on the 1990 IOM cut points: BMI <19.8 kg/m^2 (underweight); BMI 19.8-26.0 kg/m^2 (normal weight); BMI 26.1-29.0 kg/m^2 (overweight); BMI >29.0 kg/m^2 (obese).(28) After delivery, gestational weights at each prenatal visit were abstracted from

the medical chart and used to determine total gestational weight gain from beginning to end of pregnancy.

Accurate assessment of adequate weight gain must take into account that women deliver at different gestational ages and the fact that participant weight at the time of delivery is usually not recorded. To determine weight gain adequacy, we calculated the expected weight gain for a specific gestational age and BMI status, using the following equation: for a given BMI status, expected gain = [recommended first total weight gain by week 13 + (gestational age in weeks at delivery – 13) X (rate of weight gain specific for the BMI)].(7) For example, expected weight gain for an underweight woman (BMI<19.8 kg/m^2) whose weight was measured at 38 weeks gestation would be 15.7 kg, or 34.6 lbs. [3.2kg + (38 weeks gestation – 13) X (.5kg/wk)].(7)

We categorized weight gain adequacy as inadequate, adequate, or excessive. Adequacy was defined based on predetermined ranges specific to pregravid BMI and expressed as the ratio of observed weight gain/expected weight gain, as previously used by Siega-Riz et al and others.(7, 83). The predetermined ranges are displayed in Table 1.3.

Postpartum weight retention. We calculated postpartum weight retention as the difference between body weight at three months postpartum as measured at the home visit by PINPost staff and pregravid weight ascertained by maternal self-report at the first prenatal visit. Pregravid weights were checked for biological plausibility and compared to the weight recorded at the first prenatal visit. Large discrepancies were independently evaluated for reasonableness in light of gestational age at first prenatal visit. Unreasonable weights were replaced by imputed weights using a formula based on expected weight gain for a given gestational age (as determined from date of LMP or first trimester ultrasound), n=25 (3.8%). We generated two outcome variables for postpartum weight retention: a continuous variable in kg, and as a three-level categorical variable of 0-5 lbs, 5.1-10 lbs, and >10 lbs retention (0-2.2 kg, 2.3-4.5 kg, and >4.5 kg, respectively).

Physical activity. Participants completed a physical activity questionnaire at the three-month home visit. The questionnaire included questions about moderate and vigorous physical activity (defined as at least some increase in heart rate) in the areas of work, childcare, transportation, household work, and recreation. Women were asked to recall their activities in the seven days prior to the interview. For this analysis, we scored the questionnaire based on self-report of perceived intensity, whereby participants rated their activities that caused at least some increase in heart rate as fairly light, somewhat hard, or hard/very hard, and indicated the length of time they spent engaged in each activity. The length of time and frequency of participation in each activity were multiplied and summed for the week for each of the three intensity levels. Total activity was calculated by adding up the time per week spent in fairly light, somewhat hard, and hard/very hard activities for all activities. Recreational activity was calculated in the same manner but limited to time spent in recreational activities. The questionnaire was evaluated for test-retest reliability in a sample of 109 women, with a high intra-class correlation coefficients of 0.84, 95% CI 0.77-0.89.

We generated the physical activity advice exposures in the same manner as the weight loss advice exposures: received physical activity advice (yes/no); received physical activity advice from a provider (yes/no); followed provider advice, did not follow provider advice, and did not receive provider advice about physical activity. We then created physical activity outcomes separately for total and recreational physical activity levels. We examined activity in its continuous form of self-reported hours/week spent fairly light, somewhat hard, and hard/very hard (based on a woman's perceived intensity. For total physical activity, we also divided the continuous outcome into tertiles of low, medium, and high, using low as the referent category. Tertiles allowed us to examine the outcome in a categorical form while still retaining evidence of a trend similar to the variable in its continuous form. We also created a categorical outcome variable for recreational activity. Two-hundred and nine participants

(32.1%) reported no recreational activity. Because those reporting no activity represented a sizeable and distinct group, we grouped them together and divided the remaining population at the median, separating subjects at or below the median from those above the median. Thus the three categories for recreational activity were: no activity, activity at or below the mean, and activity above the mean. Those with no activity were coded as the referent category. In addition, we dichotomized total physical activity in terms of having met either the Centers for Disease Control/American College of Sports Medicine (CDC/ACSM) recommendations for moderate activity or the ACSM recommendations for vigorous activity, creating the outcome of “met recommendations, yes or no”.

Table 1.1 Total gestational weight gains recommended by the Institute of Medicine, 1990(28)

Maternal body mass index (kg/m^2)	Description	Recommended gestational weight gain
<19.8	Underweight	28—40 lb (12.7--18.2 kg)
19.8 — 26.0	Normal Weight	25—35 lb (11.4—15.9 kg)
26.1— 29.0	Overweight	15—25 lb (6.8—11.4 kg)
>29.0	Obese	>15 lb (>6.8 kg)

Table 1.2 PIN 3 and PinPost Data Collection – Points of Contact and Procedures

PIN 3

Recruitment at Prenatal Visit (≤20 weeks' gestation. Collected in clinic by trained recruiters.
- Sign informed consent
- Collect basic demographic data
- Discuss preferred times to be contacted for scheduling the first phone interview
- Complete body image assessment
- For women who agree to fasting blood draw , schedule clinic visit
- For women who do not agree to fasting blood draw, collect saliva, blood, and genital tract specimens
- Distribute self-administered psychosocial questionnaire

Clinic Visit #1 (≤20 weeks gestation) Collected in clinic by trained study personnel and ultrasonographer.
- Collect saliva, blood, and genital tract specimens
- Perform uterine flow ultrasound

Telephone Interview #1 (17-22 weeks gestation) Collected via phone by trained interviewers.
- Collect demographic information
- Collect information pertaining to general health, psychosocial factors, physical activity, reproductive history, vaginal bleeding, baby's father's characteristics

Clinic Visit #2 (24-29 weeks gestation) Collected in clinic by trained study personnel and ultrasonographer.
- Collect saliva, fasting blood, genital tract, and urine specimens
- Perform cervix and uterine flow ultrasounds
- Distribute self-administered psychosocial questionnaire
- Distribute Food Frequency Questionnaire

Telephone Interview #2 (27-30 weeks gestation) Collected via phone by trained interviewers.
- Collect information including but not limited to general health status, health behaviors, infant feeding, psychosocial factors, community factors, physical activity during pregnancy, eating and weight gain attitudes, provider advice about weight gain and physical activity

After Delivery – Collected in the hospital postpartum ward by trained interviewers and medical abstractors.
- Monitor daily delivery logs to collect PIN women delivery information
- Interview about physical activity collect hair specimen, collect placenta
- Abstract medical charts for reproductive history, weight gain, pregnancy complications, labor and delivery events

PinPost

Recruitment via Telephone (6 weeks postpartum) Collected via phone by trained interviewers.
- Obtain consent
- Schedule a 3-month home visit

3-month Home Visit – Collected in participant's home by two trained interviewers.
- Take physical measurements of weight, height and body fat percent
- Collect information including but not limited to general health status, eating attitudes, body image, infant feeding, psychosocial factors, physical activity postpartum, weight loss postpartum, provider advice about weight retention and physical activity postpartum

12-month Home Visit – Collected in participant's home by two trained interviewers.
- Take physical measurements of weight, height and body fat percent
- Collect information including but not limited to general health status, eating attitudes, body image, infant feeding, psychosocial factors, physical activity postpartum, weight loss postpartum, provider advice about weight retention and physical activity postpartum
- Administer revised restraint scale and collect information about food security

Table 1.3 Range of adequate weight gain specific to pregravid BMI.

Pregravid BMI	Inadequate	Adequate	Excessive
Underweight	<75%	75-110%	>110%
Normal weight	<90%	90-120%	>120%
Overweight	<80%	80-120%	>120%
Obese	<100%	100-120%	>120%

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CHAPTER 2

MATERNAL ATTITUDE ABOUT PREGNANCY WEIGHT GAIN AND WEIGHT GAIN ADEQUACY

Introduction

Most pregnant women gain weight that is above or below medical recommendations (1-4). Both total and the pattern of weight gain pose serious health risks for mother and baby, including low birth weight and preterm delivery for women with inadequate gains (5), and macrosomia (6), cesarean section (7), impaired glucose tolerance (8), and postpartum weight retention (9) among those with excessive gains. Excessive gain is of particular concern for women's health given both the steadily rising rates of overweight and obesity among reproductive-aged women and the contribution of excessive pregnancy weight gain and postpartum weight retention to these rates (10).

Some effort has been made to identify and address factors leading to inadequate or excessive gain, including an examination of the influence of maternal attitude toward pregnancy weight gain (11-15). Earlier studies have identified a link between attitude and weight gain, such that women with a negative attitude were more likely to gain inadequately during pregnancy (14) or excessively (12). Still others noted an association between pregravid Body Mass Index (BMI) and attitude about weight gain – women who begin pregnancy overweight or obese were more likely to have a negative attitude about pregnancy weight gain relative to their normal weight counterparts (12, 13). Interestingly, on the whole, weight gain attitude was not found to differ by socio-demographic factors such as race or income. However, not all studies found an association between attitude and weight

gain (11, 15), suggesting a need for continued investigation. In particular, it is not clear if weight gain attitude as commonly measured predicts excessive gain as well as it predicts inadequate gain. The purpose of our study was to evaluate the relationship between pregnant women's attitudes toward weight gain and adequacy of gain in a North Carolina sample. Specifically, we set out to answer if attitudes about weight gain differ by socio-demographic factors, including pregravid body size, and if women's attitudes about weight gain during pregnancy are associated with the risk for inadequate or excessive gain.

Methods

Study Design and Sample

Data for this study come from the Pregnancy, Infection, and Nutrition (PIN) Study, a longitudinal, prospective cohort study of risk factors for preterm birth in central North Carolina. From January 2001 and June 2005, study staff recruited women from public and private prenatal care clinics at the University of North Carolina (UNC) Hospitals at their second prenatal visit. Eligible women included English-speaking women less than 20 weeks' gestation who were at least 16 years old, had a singleton fetus, planned to continue care at the clinic, and had access to a telephone for interviews. Data on socio-demographics, medical history, current pregnancy, and health behaviors were collected via clinic visits, phone interviews, and self-administered questionnaires. Biological specimens were collected at various times and medical record information was abstracted after delivery. A total of 2006 women were recruited under these protocols. (Please refer to http://www.cpc.unc.edu/projects/pin for further information on study protocols.) The Institutional Review Board of the University of North Carolina at Chapel Hill approved all study protocols, including a waiver of HIPAA regulations.

We limited our sample to 1,626 women who were recruited between April 2002, when the attitude questionnaire became part of data collection, and June 2005, when

recruitment ended. We excluded 282 women (17.0%) who did not complete the second phone interview (during which the weight gain attitudes questionnaire was administered), 61 women (3.8%) who did not have medical abstracts (the source for weight gain data), 17 (1.0%) without weight gain data, and 11 women (0.7%) with infant or fetal deaths. Forty-eight (3.8%) of the remaining women had two pregnancies in the cohort, the second of which was dropped to remove issues of dependency. Fifteen (1.2%) of the 1,207 remaining women completed the second phone interview but did not complete the weight gain attitudes questionnaire, resulting in a final analysis file of 1,192 women.

Exposure Measurement - Maternal Attitude toward Pregnancy Weight Gain

Maternal attitude toward pregnancy weight gain was assessed in a telephone interview administered by a trained interviewer when study participants were between 27-30 weeks' gestation, using the Pregnancy and Weight Gain Attitude Scale (PWGAS) (14). The scale is comprised of eighteen statements about gaining weight during pregnancy that are scored on a 5-point Likert scale ranging from strongly disagree to strongly agree. A composite attitude score was determined by summing all the questions. Before summing, 10 negative statements were reverse-scored so that a response of 'strongly agree' was equal to a score of '1'. One of these ten statements, 'I would like to gain between 11 and 20 pounds' was considered a positive statement for women with a pregravid BMI >26.0 but negative for those whose pregravid BMI was ≤26.0; it was therefore reverse-scored for the latter group of women.

In accordance with the developers of the PWGAS, we dichotomized attitude into a positive versus a negative attitude using the following formula: sum of all questions /18=X. Possible scores range from 18-90. The composite score of X ≥3 =a positive attitude, whereas X <3 =a negative attitude (14). The content validity of the PWGAS was assessed in the original study using a panel of 30 external judges, including pregnant women, who

determined which items were appropriate statements of weight gain attitude and should be included in the scale (14). The authors field-tested the scale and assessed its item discrimination, dropping items that did not differentiate between a negative and positive attitude.

Reliability was rtt=0.67, as determined using the Spearman Brown Prophecy formula (14), and 0.80 and 0.65 for negative and healthy attitudes, respectively, using the Cronbach's alpha as tested in a largely white, rural population (16). The scale had test-retest reliability across the latter half of pregnancy, with a correlation score of r=0.68, p<0.001 (11). Construct validity in a predominantly white, rural population was moderate, with an F score of 68.23 (16).

Outcome Measurement - Adequacy of Gestational Weight Gain

Adequacy of gestational weight gain was defined as gaining within predetermined ranges of the 1990 Institute of Medicine (IOM) guidelines. Self-reported pregravid weight and height measurements were collected at the time of recruitment and used to calculate pregravid BMI. Women were categorized into BMI categories based on the 1990 IOM cut points: BMI <19.8 kg/m2 (underweight); BMI 19.8-26.0 kg/m2 (normal weight); BMI 26.1-29.0 kg/m2 (overweight); BMI >29.0 kg/m2 (obese).(17) After delivery, gestational weights at each prenatal visit were abstracted from the medical chart. The last measured weight before delivery (commonly within 1 week of delivery) was used to determine total gestational weight gain from beginning to end of pregnancy.

Accurate assessment of adequate weight gain must take into account that women deliver at different gestational ages and the fact that participant weight at the time of delivery is usually not recorded. To determine weight gain adequacy, we calculated the expected weight gain for a specific gestational age and BMI status.(18) We categorized weight gain adequacy as inadequate, adequate, or excessive. Adequacy was defined based on

predetermined ranges described in Table 2.1 and specific to pregravid BMI and expressed as the ratio of observed weight gain/expected weight gain.(1, 8)

Covariates

Covariates included maternal race (African American, Caucasian), age (in years), education level (less than high school, completed high school, and greater than high school), parity (0, 1, 2, 3 or more children), poverty level (≤185% of the Federal Poverty Level (FPL), >185% FPL) , moderate to vigorous physical activity in total hours/week in the week prior to the interview, and advice about weight gain during pregnancy ('received advice at any time during pregnancy up until the time of the interview (27-30 weeks' gestation), yes or no'). Pregnancy and maternal health status indicators were measured using prenatal records which indicated the presence or absence of: gestational diabetes, pregnancy-induced hypertension, preterm labor, vaginal bleeding, pre-existing diabetes, and smoking during pregnancy. All covariate data are based on maternal self-report with the exception of the maternal health status variables (which are clinically determined except for smoking) and the physical activity variables (some of which involve classifying participant activities according to published metabolic equivalents, or METs (19), the amount of oxygen used by the body when performing activity). Pregravid BMI is based on self-reported weight at the first prenatal visit and a measured height. Weight cycling, dieting history, and restrictive eating behaviors were assessed using the Revised Restraint Scale (20, 21).

Data Analysis

Analysis included generation of study population descriptive statistics, measured by prevalence (%) of characteristics. Chi square and t-test statistics were used to identify any differences in population characteristics by attitude type and by weight gain adequacy, with statistical significance set at $p < 0.05$. We calculated chi square statistics comparing each

item in the PWGAS with the outcome of weight gain adequacy to determine any differences in adequacy by each item. We also compared the percent distribution of responses for each item across three categories of responses (disagree/strongly disagree, neither agree nor disagree, and agree/strongly agree) and then stratified the distribution by weight gain adequacy (inadequate, adequate, excessive) to examine whether there were any differences.

We analyzed the exposure (attitude) and the outcome (weight gain adequacy) using both linear and categorical forms of the variables. We explored the outcome as: total pregnancy weight gain (in kg); adequacy of weight gain expressed as the ratio of observed/expected gain (in kg); and adequacy of weight gain as a categorical variable according to IOM recommendations (adequate vs. inadequate and adequate vs. excessive). The exposure was examined three ways: as a continuous variable, in tertiles (results not shown), and as a dichotomous positive vs. negative variable. Results were similar when attitude was a continuous variable or in tertiles and therefore the continuous form was used. We used linear regression to examine the exposure and outcome in their continuous forms. To examine the variables in their categorical forms, we performed a multivariable analysis using a generalized linear model to estimate the adjusted risk of inadequate or excessive gain associated with maternal attitude. Inadequate and excessive gains were modeled separately, with adequate gain as the referent variable in each model.

Potential confounders identified from the literature included: pregravid BMI; maternal race, education, age, and socioeconomic status; parity; physical activity during pregnancy; history of dieting, weight cycling, or restrictive eating behaviors; and receipt of provider advice about weight gain during pregnancy. Race was limited to African American and Caucasian; other races were excluded due to low numbers in the population (n=101, 8.5%). Potential confounders that did not change the coefficient (for the linear regression models) or the relative risk (for the generalized linear models) by 10% or more were dropped from

the model. Pregravid BMI, maternal race, and provider advice were hypothesized to be potential effect measure modifiers and were tested prior to assessing confounding by comparing the relative risks for inadequate or excessive gain among women with a negative attitude versus a positive attitude. Effect measure modification was considered present if the Mantel Hanzel test for homogeneity detected a difference in odds ratios between groups ($p<0.1$). Intercooled Stata 9.2 (released April 14, 2006, by StataCorp, College Station, Texas) was employed for all statistical analyses.

Results

Population characteristics

Table 2.2 provides descriptive characteristics of the study population. The majority of the population was white and married, with middle to upper socio-economic status and a greater than high school education. About half had a history of dieting and about half reported having received advice about weight gain during pregnancy. Nearly all of the women had a positive attitude toward pregnancy weight gain. When compared to women with a positive attitude, those with a negative attitude were more often African American, low-income, and overweight or obese before pregnancy, and more likely to have a history of dieting or weight cycling and a greater amount of physical activity during pregnancy ($p<0.05$). Average weight gain was 33.6 lbs (15.2 kg). There were no statistically significant differences in the study sample compared to the overall PIN population.

Adequacy of weight gain

Adequate weight gain decreased markedly with increasing pregravid BMI: 47% of underweight women gained adequately, compared to only 25% of normal weight women, and 8% and 6% of overweight and obese women, respectively. Conversely, excessive weight gain tended to increase, with the majority of women in the normal weight, overweight,

and obese groups gaining in excess of recommendations: 32% of underweight women gained excessively compared to 64%, 85%, and 75% for normal weight, overweight, and obese women, respectively. Less than a quarter of each pregravid BMI group gained less than the recommended amount of weight during their pregnancy.

Maternal attitude and risk for inadequate or excessive weight gain

Several items on the questionnaire showed an association with excessive pregnancy weight gain. Table 2.3 displays overall mean scores for each questionnaire item, as well as the mean score and percent stratified by adequacy of weight gain. Table 2.3 also includes the percent of women answering agree/strongly agree, neither agree nor disagree, and disagree/strongly disagree for each item, stratified by adequacy. Excessive gain, compared to adequate or inadequate, was more common ($p<0.05$) among women who worried about getting fat, who were embarrassed and felt unattractive because of their weight gain, who were embarrassed to be weighed by the nurse at their prenatal visits, and who were bothered by not being able to wear current fashions while pregnant. (Table 3) Women with a targeted gain of 11-20 lbs were more likely to gain inadequately compared to women without this goal, while women desiring to gain 21-30 lbs were more likely to gain in the adequate range compared to counterparts without such a target. Most women indicated an opinion about each questionnaire item, with less than a quarter of women in any weight gain category answering 'neither agree nor disagree'. To determine if respondents with a neutral attitude were diluting the strength of a positive attitude, we re-categorized the positive attitude to exclude respondents answering neither agree nor disagree. The results remained unchanged (data not shown).

In the linear regression analysis, a 10-unit increase in the questionnaire score (indicating a more positive attitude) resulted in a 0.6 kg decrease in pregnancy weight gain ($p<0.05$, after adjusting for pregravid BMI, maternal race, parity, socio-economic status, and

weight cycling) and a 0.06 unit decrease in the weight gain adequacy ratio ($p<0.05$, adjusting for pregravid BMI and weight cycling).

Table 2.4 provides the crude and adjusted relative risks and 95% confidence intervals for maternal attitude toward pregnancy weight gain and the risk of inadequate or excessive gain. We did not detect effect measure modification by pregravid BMI, race, or self-reported receipt of provider advice about weight gain and thus one estimate each is reported for inadequate and excessive gain. The crude analysis showed a moderate risk for inadequate gain compared to those with adequate weight gain among women with a negative weight gain attitude, which remained after adjustment for pregravid BMI, maternal race, and parity. For the outcome of excessive weight gain, a negative attitude compared to a positive one had a weak effect on weight gain at the crude level which attenuated towards the null once we accounted for differences in pregravid BMI.

Discussion

The well-documented negative effects of gaining weight outside recommendations warrant an examination of factors that might predict adequate weight gain. Our results do not support an association of excessive weight gain with the overall composite score on the PWGAS which was used to measure maternal weight gain attitudes, but do show a moderate association with inadequate gain. We found no association between attitude and maternal age, provider advice about weight gain, gestational diabetes, pregnancy-induced hypertension, or weight gain adequacy. Attitude was associated with pregravid BMI, race, income status, parity, education, diet history, physical activity in the second trimester, pre-existing hypertension, pre-eclampsia or eclampsia, and smoking in the first six months of pregnancy. Not surprisingly, pregravid BMI was a strong predictor of weight gain, as found in other studies (3, 11, 15, 22).

Others studies using the PWGAS have suggested that pregravid body size influences attitude. Copper and colleagues' prospective study of 1,000 multiparous, predominantly overweight/obese women found that the attitude score overall was not related to pregnancy weight gain but that overweight/obese women had more negative attitudes toward pregnancy weight gain than underweight women (11). Similarly, Stevens-Simon et al found that a greater proportion of the 99 adolescents with high pre-pregnancy weights had a negative attitude about weight gain than their lower-weight adolescent counterparts (13). In contrast, a prospective study of 622 mainly white, rural-dwelling women did not find that attitude about pregnancy weight gain was related to weight gain (15). The authors do not offer an explanation for the lack of association. Our study found a strong association between pregravid BMI and weight gain attitude: underweight and normal weight women were more likely to have a positive vs. a negative attitude, while the converse was true for overweight and obese women, most of whom had a negative attitude toward weight gain.

Although we found little association between weight gain and the overall PWGAS score, a handful of individual items on the scale showed a strong association with weight gain, suggesting that these items might prove useful in identifying women at risk for inadequate or excessive gain. Among earlier studies of weight gain and attitude, most (11-13, 16, 23) though not all (15), found weight gain attitudes to be associated with pregnancy weight gain, but, similar to our findings, these associations were frequently not with the composite score on the PWGAS but more often with individual items.

It is possible that excessive weight gain in pregnancy predicts attitude rather than the other way around. Copper et al administered the PWGAS at two time periods during pregnancy, at approximately 20 weeks' and approximately 32 weeks' gestation (11). The authors found a strong correlation ($r=0.68$, $p<0.001$) between attitudes assessed at the two time periods, suggesting that attitudes early in pregnancy may remain stable throughout pregnancy. Stevens-Simon et al administered the PWGAS upon entry into prenatal care and

still found that 4 of the 18 scales items showed an association with pregnancy weight gain (13). Thus, though it cannot be ruled out, our use of the PWGAS measured at 27-30 weeks' gestation does not suggest reverse causality.

The PWGAS was developed greater than twenty years ago, during a time when practitioners were more concerned with too little pregnancy weight gain rather than too much. At that time, the authors demonstrated an association between a low score (indicating a negative attitude) on the PWGAS and inadequate weight gain, and our findings confirm that association today. However, the scale's poor prediction of excessive weight gain might suggest that attitudes have changed over time to a more embracing attitude toward pregnancy weight gain, and one that does not necessarily conflict with excessive gain. The remarkable difference in the proportion of women with a negative weight gain attitude in the PWGAS development study compared to our study [41% (12/29) (14) versus 4.1% (49/1,192), respectively] is evidence of such a change.

A primary study limitation is the assessment of weight gain attitude. Because attitude is measured late in pregnancy, we cannot be sure of the direction of causation as previously described. In addition, the dichotomy of positive vs. negative attitude may not adequately capture distinct attitude types. Indeed, in our study, 96% of the population had a positive attitude, indicating very little variation in attitude in the population when measured dichotomously. The response of "neither agree nor disagree" was included in the score for a positive attitude and this may have diluted the positive attitude category. However, we conducted a sensitivity analysis, removing all neutral responses and comparing agree/strongly agree to disagree/strongly disagree and found no differences in the results (results not shown).

Our data, combined with the inconclusive results of earlier studies, indicate a need for continued work in this area. In particular, the lack of significant association in our data and others (11, 13, 15) between the composite score on the PWGAS and weight gain above

recommendations suggests a need for a revised tool that will better identify attitudes that predict excessive gain, and that ultimately may be utilized for intervention programs aimed at preventing excessive pregnancy weight gain.

Table 2.1. Ranges of weight gain adequacy specific to pregravid BMI, expressed as percent of expected gain based on 1990 Institute of Medicine guidelines.

Pregravid BMI	Inadequate	Adequate	Excessive
Underweight	<75%	75-110%	>110%
Normal weight	<90%	90-120%	>120%
Overweight	<80%	80-120%	>120%
Obese	<100%	100-120%	>120%

Table 2.2 Distribution of maternal characteristics overall and by attitude about pregnancy weight gain.

Maternal Characteristic	Total sample (n=1,192)		Attitude Toward Pregnancy Weight Gain			
			Positive (n=1,143)		Negative (n=49)	
	n	%	n	%	n	%
Race/Ethnicity*						
Non-Hispanic Caucasian	880	73.9	852	74.6	28	57.1
Non-Hispanic African American	210	17.6	195	17.1	15	30.6
Other	101	8.5	95	8.3	6	12.2
Education level*						
< High school	66	5.5	60	5.3	6	12.2
High school	148	12.4	137	12.0	11	22.5
> High school	978	82.1	946	82.8	32	65.3
Income status*						
≤ 185% Federal poverty level	225	19.6	207	18.8	18	39.1
> 185% Federal poverty level	923	80.4	895	81.2	28	60.9
Marital status						
Single	225	18.9	212	18.6	13	26.5
Married	928	77.9	894	78.2	34	69.4
Separated, divorced, widowed	39	3.3	37	3.2	2	4.1
Age						
16-18	33	2.8	31	2.7	2	4.1
19-24	206	17.4	197	17.2	9	18.4
25-29	349	29.1	334	29.2	15	30.6
30-34	408	34.4	394	34.5	14	28.6
35-47	196	16.4	187	16.4	9	18.4
Parity (live births + stillbirths) *						
0 (Nulliparous)	593	49.8	575	50.3	18	36.7
1	393	33.0	373	32.8	20	40.8
2	145	12.2	140	12.2	5	10.2
3+	61	5.1	55	4.7	6	12.2
Pre-pregnancy BMI*						
Underweight	171	14.4	169	14.8	2	4.1
Normal weight	612	51.3	594	52.0	18	36.7
Overweight	134	11.2	126	11.0	8	16.3
Obese	275	23.1	254	22.2	21	42.9
Diet History						
Weight Cycling*						
Yes	517	50.1	490	49.4	27	67.5
No	515	49.9	502	50.6	13	32.5
Dieting*						
Yes	582	52.2	550	51.4	32	72.7
No	533	47.8	521	48.7	12	27.3
Restrained Eating						
Yes	520	50.5	492	49.7	28	71.8
No	509	49.5	498	50.3	11	28.2
Health Conditions						
Pre-existing Hypertension*						
Yes	85	7.2	77	6.7	8	16.3
No	1,107	92.8	1,066	93.3	41	83.7
Pre-existing Diabetes						
Yes	41	3.4	39	3.4	2	4.1
No	1,151	96.6	1,104	96.6	47	95.9
Pregnancy-Induced Hypertension						
Yes	299	25.1	281	24.6	18	36.7
No	893	74.9	862	75.4	31	63.3
Gestational Diabetes						
Yes	49	4.1	47	4.1	2	4.1
No	1,143	95.9	1,096	95.9	47	95.9
Pre-eclampsia/Eclampsia*						
Yes	54	4.5	48	4.2	6	12.2
No	1,138	95.5	1,095	95.8	43	87.8

Smoked first 6 months of pregnancy*						
Yes						
No	126	10.6	111	9.7	15	30.6
	1,066	89.4	1,032	90.3	34	69.4
Received weight gain advice						
Yes	633	53.1	606	53.0	27	55.1
No	559	46.9	537	47.0	22	44.9
Adequacy of weight gain						
Adequate	264	22.2	259	22.7	5	10.2
Inadequate	163	13.7	157	13.7	6	12.2
Excessive	765	64.2	727	63.6	38	77.6
Attitude toward pregnancy weight gain						
Positive						
Negative	1150	95.9	n/a	n/a	n/a	n/a
	49	4.1				
	n=1,175		n=1,126		n=49	
First Trimester Physical Activity	Median (IQ† range)		Median (IQ range)		Median (IQ range)	
Total activity hours in last week	4.5 (2.2, 8.5)		4.5 (2.2, 8.3)		5.2 (2.8, 12.3)	
Total recreation hours in last week	1.0 (0.0, 2.5)		1.0 (0.0, 2.5)		1.0 (0.0, 2.5)	
Second Trimester Physical Activity	n=1,158		n=1,111		n=47	
Total activity hours in last week	4.1 (1.9, 7.8)		4.0 (1.8 , 7.6)		5.5 (2.8, 10.3)	
Total recreation hours in last week	1.0 (0.0, 2.5)		1.0 (0.0, 2.4)		1.0 (0.0, 2.5)	

*Significant differences between those with a positive attitude and those with a negative attitude (chi2 test of overall distribution $p<0.05$ for categorical variables; two-sided t-test of sample means for continuous variables $p<0.05$)

†Interquartile range

Missings uniformly excluded; percents may not add due to rounding.

Table 2.3. Mean score for each item on the PWGAS (overall and stratified by adequacy of weight gain), and percent of women responding within combined agreement categories stratified by adequacy of weight gain.

Attitude Question	Mean Score	Mean Score			Percent Agree/ Strongly Agree			Percent Neither Agree nor Disagree			Percent Disagree/ Strongly Disagree		
		Ad[a]	In[b]	Ex[c]	Ad	In	Ex	Ad	In	Ex	Ad	In	Ex
Overall	3.7	3.8	3.7	3.6	Not applicable								
a) I worry that I may get fat during this pregnancy.*	3.1	3.4	3.6	2.9	34.1	27.0	50.5	6.8	4.9	5.0	59.1	68.1	44.6
b) I would like to keep gain between 21 and 30 pounds during this pregnancy.*	3.6	3.8	3.4	3.6	79.2	62.0	70.1	7.2	8.0	8.8	13.6	30.1	21.2
c) I am trying to keep my weight down so I don't look so pregnant.	4.1	4.2	4.2	4.2	3.4	2.5	6.0	2.3	1.8	2.9	94.3	95.7	91.1
d) I would like to gain between 11 and 20 pounds during this pregnancy.*	3.6	3.9	3.4	3.5	18.9	43.6	20.4	4.2	4.3	5.1	76.9	52.2	74.5
e) As long as I'm eating a well-balanced diet, I don't care how much I gain during this pregnancy.	3.4	3.4	3.4	3.4	64.8	60.7	63.5	4.6	7.4	4.3	30.7	31.9	32.2
f) I think a pregnant woman is beautiful.	4.0	4.0	4.0	4.0	86.7	87.7	88.4	10.2	10.4	7.2	3.0	1.8	4.4
g) I'm proud of looking pregnant.	4.0	4.0	4.0	4.0	87.5	89.0	89.0	8.3	6.8	6.0	4.2	4.3	5.0
h) I like being able to gain weight for a change.	2.8	2.9	2.8	2.8	34.5	30.1	33.7	20.5	17.2	15.8	45.1	52.8	50.5
i) I am embarrassed at how big I have gotten during this pregnancy.*	4.0	4.2	4.2	3.9	3.4	3.7	12.3	1.9	2.5	4.3	94.7	93.9	83.4
j) I would gain 40 pounds if it meant my baby would be healthier.	4.0	4.0	3.8	4.1	73.4	77.5	70.6	2.4	2.8	2.9	24.2	19.7	26.5
k) I like wearing maternity clothes.	3.1	3.1	3.0	3.1	50.0	44.8	48.6	14.0	10.4	12.0	36.0	44.8	39.4
l) The weight I gain during my pregnancy makes me feel unattractive.*	3.5	3.6	3.7	3.4	18.9	16.7	29.5	6.4	4.3	6.7	74.6	79.1	63.8
m) I'm embarrassed whenever the nurse weighs me.*	3.8	4.1	4.0	3.7	4.2	5.5	17.7	2.7	2.5	3.8	93.2	92.0	78.6

n) It bothers me that I can't wear what is in style while I'm pregnant.*	3.7	3.8	3.7	3.6	17.1	17.2	24.3	4.9	4.9	3.1	78.0	77.9	72.6
o) I feel that women have to be especially careful about getting fat during pregnancy.	3.3	3.4	3.3	3.3	30.75	33.1	32.2	7.6	6.1	9.7	61.7	60.7	58.2
p) If I gain too much weight one month, I will try to keep from gaining the next month.	3.8	3.9	3.8	3.8	11.4	16.6	13.3	4.6	0.6	2.8	84.1	82.8	83.9
q) Just before I go to the doctor, I try not to eat.	4.2	4.3	4.2	4.2	0.4	2.5	2.8	0.0	0.0	0.9	99.6	97.6	96.3
r) I would gain 35 pounds if it meant my baby would be healthier.	4.1	4.1	4.0	4.1	93.9	90.2	93.5	1.9	1.2	2.4	4.2	8.6	4.2

[a] Ad=Adequate
[b] In=Inadequate
[c] Ex=Excessive
*A statistically significant difference in percent of respondents in each adequacy category (adequate, inadequate, excessive gain) answering within combined agreement categories, $p<0.05$.

Table 2.4 Maternal attitude toward pregnancy weight gain and risk for inadequate or excessive gestational weight gain.[a]

	Inadequate weight gain						Excessive weight gain					
Attitude	n	%	RR[b]	95% CI[c]	ARR[d]	95% CI	n	%	RR	95% CI	ARR[e]	95% CI
Positive	157	96.3	1.0	n/a	1.0	n/a	727	95.0	1.0	n/a	1.0	n/a
Negative	6	3.7	1.45	0.83-2.50	1.42	1.22-1.65	38	5.0	1.20	1.07-1.34	1.03	0.94-1.12

RR= Relative Risk; ARR=Adjusted Relative Risk

[a]Adequate weight gain is the referent category.

[b]RR=relative risk.

[c]CI=confidence interval.

[d]Adjusted for pregravid Body Mass Index (BMI), maternal race, and parity.

[e]Adjusted for pregravid BMI.

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CHAPTER 3

PROVIDER ADVICE ABOUT PREGNANCY WEIGHT GAIN AND ADEQUACY OF WEIGHT GAIN

Introduction

In 1990, the Institute of Medicine (IOM) provided new pregnancy weight gain guidelines, liberalizing earlier recommendations and tailoring them to a woman's pre-pregnancy body mass index (BMI).(1) Since that time, these guidelines have been widely published and adopted by the American College of Obstetrics and Gynecology and the American Academy of Pediatrics.(2) In spite of this, the majority of pregnant women continue to gain weight outside recommendations(3-5)and these numbers have increased over time – for example, 37% of women gained in excess of recommendations in 1993 compared to 46% in 2004.(6) Gaining outside recommended ranges increases the risk of preterm delivery for women with inadequate gain,(7) and macrosomia(8), cesarean section(9), impaired glucose tolerance(10) and postpartum weight retention(11) among those with excessive gain.

Remarkably little is known about why pregnant women gain weight outside the IOM recommendations. Researchers have found that pregnant women who reported being advised about the appropriate amount of weight to gain during pregnancy were more likely to gain within the recommended range than women who did not report receiving such advice.(12-15) However, this association is based on a handful of studies, most of which were conducted prior to or soon after the 1990 IOM guidelines were made public. In a 2006 workshop convened by the IOM specifically to address pregnancy weight gain, report

authors note that “despite the availability of the IOM recommendations and an effort to publicize their availability, their use and compliance are not understood.”(6, p.2)The committee called for future research on the role of provider advice in helping women achieve targeted pregnancy weight gain goals.

Further, although the physiology of weight gain with regard to energy intake and expenditure is well-understood, there is little research examining the effect of diet or physical activity during pregnancy on pregnancy weight gain.(16, 17) Total energy intake in pregnancy has been associated with maternal weight gain in general and excessive weight gain specifically,(18) while dietary advice to reduce intake was shown to be effective in reducing weekly weight gain among overweight women and those with high pregnancy weight gain.(16)

The effect of physical activity on weight gain is less clear. Several studies, in which activity levels are assessed via interview or questionnaire, have shown no association between physical activity and gestational weight gain.(19-21) However, two additional studies did find an effect of exercise on weight gain, such that physically active women gained less overall pregnancy weight than sedentary women.(22, 23) The latter two studies assessed activity levels with a questionnaire as well and used clinical records for weight measurements. The lack of research in this area coupled with the inconclusive results of existing studies points to the need for further examination of the association of diet and physical activity in pregnancy with pregnancy weight gain.

This study’s goal was to examine the association of provider advice about weight gain with measured pregnancy weight gain in a cohort of pregnant women. We aimed to both determine if the previously identified positive association between advice and weight gain continues to hold true in light of the 1990 IOM recommendations and the passage of time, and to inform interventions aimed at decreasing the proportion of women who gain too little or too much weight during pregnancy. Specifically, we set out to examine if provider

advice about weight gain during pregnancy was associated with the risk for inadequate or excessive pregnancy weight gain, and to examine maternal diet and physical activity levels in pregnancy as potential mediators between provider advice and pregnancy weight gain.

Methods

Study Design and Sample

Data for this study came from the Pregnancy, Infection, and Nutrition Study 3 (PIN), a longitudinal cohort study of risk factors for preterm birth conducted at the University of North Carolina (UNC) Hospitals in central North Carolina. PIN staff recruited women from prenatal care clinics at their second prenatal visit. Eligible women were English-speaking women less than or equal to 20 weeks' gestation who were at least 16 years old, had a singleton fetus, planned to continue care at the clinic, and had access to a telephone for interviews. Data on sociodemographics, medical history, current pregnancy, and health behaviors were collected via clinic visits, in-depth phone interviews, and self-administered questionnaires. Between January 2001and June 2005, a total of 2,006 women were recruited. The Institutional Review Board of the University of North Carolina at Chapel Hill approved all study protocols.

Exposure Measurement – Provider Advice about Pregnancy Weight Gain

Maternal self-report of provider advice about pregnancy weight gain was obtained from a telephone interview administered by a trained interviewer at 27-30 weeks' gestation. Women were asked to answer yes or no to the following question: "At any time during this pregnancy, has a doctor, nurse, or other health professional given you advice about how much weight you should gain during pregnancy?" Women were also asked to identify the source of provider advice and to indicate whether they followed the advice.

Outcome Measurement - Adequacy of Pregnancy Weight Gain

Adequacy of gestational weight gain was defined as gaining within predetermined ranges of the 1990 IOM guidelines.(1) These guidelines delineate recommended pregnancy weight gain based on a woman's pre-pregnancy BMI. Self-reported pre-pregnancy weight and height measurements were collected at the time of recruitment and used to calculate pre-pregnancy BMI. Women were categorized into BMI categories based on the 1990 IOM cut points: BMI<19.8 kg/m^2 (underweight); BMI 19.8 – 26.0 kg/m^2 (normal weight); BMI 26.1 – 29.0 kg/m^2 (overweight); BMI >29.0 kg/m^2 (obese).(1) After delivery, gestational weights at each prenatal visit were abstracted from the medical chart. The last measured weight before delivery (commonly within 1 week of delivery) was used to determine total gestational weight gain from beginning to the end of pregnancy.

Accurate assessment of adequate weight gain should take into account that women deliver at different gestational ages, but it is hampered by the reality that participant weight at the time of delivery is usually not recorded. To determine weight gain adequacy, we calculated the expected weight gain for a specific gestational age and BMI status, using the following equation: for a given BMI status, expected gain = [recommended first total weight gain by week 13 + (gestational age in weeks at delivery – 13) X (rate of weight gain specific for the BMI)].(3) For example, expected weight gain for an underweight woman (BMI<19.8 kg/m^2) whose weight was measured at 38 weeks' gestation would be 15.7 kg, or 34.6 lbs. [3.2kg + (38 weeks' gestation – 13) X (.5kg/wk)].(3)

The outcome was explored in three different ways: 1) as a continuous variable of total pregnancy weight gain in kilograms, calculated by subtracting the pre-pregnancy weight from the last prenatal visit before delivery; 2) as a ratio of observed to expected weight gain, calculated by dividing the total weight gain in kilograms by the expected weight gain for a specific gestational age in kilograms (based on IOM recommendations), such that a value >1 indicates greater than expected gain and a value <1 indicates less than expected

gain; and 3) as a categorical variable of inadequate, adequate, or excessive weight gain, with adequacy defined based on predetermined ranges specific to pre-pregnancy BMI and expressed as the ratio of observed weight gain/expected weight gain.(24)

Covariates

Potential confounders included the socio-demographic variables of maternal race/ethnicity (Non-Hispanic African American, Non-Hispanic Caucasian), age (in years), education level (less than high school, completed high school, and greater than high school), parity (0, 1, 2, and 3 or more children), and poverty level (≤185% of the Federal Poverty Level (FPL), >185% FPL). We also evaluated pregnancy and maternal health status indicators. These variables were measured using prenatal records, which indicated the presence or absence of gestational diabetes, pregnancy-induced hypertension, preterm labor, vaginal bleeding, pre-existing diabetes, and smoking during pregnancy. Health behaviors included weight cycling, dieting history, and restrictive eating behaviors which were assessed at 27-30 weeks' gestation using the Revised Restraint Scale.(25, 26) Maternal attitude toward pregnancy weight gain was assessed at 27-30 weeks' gestation using the Pregnancy Weight Gain Attitude Scale.(27)

Potential mediators included diet and physical activity. Dietary values of carbohydrate, protein, fat, and total caloric intake were based on a modified version of the Block Food Frequency Questionnaire designed to assess diet during the previous three months.(28) Women completed this questionnaire between 24-29 weeks' gestation. In the analysis we used both the continuous forms of the dietary values as well as categorical forms divided into tertiles. Physical activity was assessed at 27-30 weeks' gestation via an extensive questionnaire in which women reported their physical activity in the week prior to the telephone interview. Participants rated their activities that caused at least some increase in heart rate as fairly light, somewhat hard, or hard/very hard, and indicated the length of

time they spent engaged in each activity. The length of time and frequency of participation in each activity were multiplied and summed for the week for each of the three intensity levels. Total activity was calculated by adding up the time per week spent in fairly light, somewhat hard, and hard/very hard activities for all activities. Recreational activity was calculated in the same manner but limited to time spent in recreational activities.

Statistical Analysis

From the 2,006 women who were recruited into PIN, we excluded 233 (11.6%) without sufficient prenatal weight gain data and 213 (10.6%) who did not complete the second phone interview (in which the provider advice question was asked). Of the remaining 1,560 women, we excluded 23 (1.5%) with fetal or infant deaths and 83 (5.3%) who had more than one pregnancy in the cohort, the second (and, in 3 cases, the third) of which was dropped to remove issues of dependency, resulting in a final analysis file of n=1,454 women.

Analysis included generation of study population descriptive statistics. Chi square and t-test statistics were used to identify any differences in population characteristics by provider advice and by weight gain adequacy, with statistical significance set at $p < 0.05$. We hypothesized that dietary intake and physical activity operated as mediators in the causal pathway between advice and pregnancy weight gain. We tested for mediation using both Baron and Kenny's criteria(29) and the Sobel test for mediation,(30) exploring the mediating variables in their continuous and categorical forms and the outcome as total, observed/expected, and adequacy of weight gain.

Maternal race and pre-pregnancy BMI were identified from the literature(12-14) as potential effect measure modifiers and were tested prior to assessing confounding by comparing the odds ratios for inadequate or excessive gain among women who reported receiving provider advice versus women who reported receiving no provider advice. Effect

measure modification was considered present if the Mantel Hanzel test for homogeneity detected a difference in odds ratios between groups ($p<0.1$). Race was limited to African American and Caucasian; other races were excluded due to low numbers in the population (n=132, 9.1%). Pre-pregnancy BMI was categorized into two groups: underweight/normal weight women and overweight/obese women. Following this, the socio-demographic, health status, health behavior, and attitude variables were assessed as potential confounders using a backward elimination method; those that did not change the beta coefficient (for the linear regression models) or the relative risk (for the generalized linear models) by 10% or more were dropped from the final model.

We used linear regression to examine the outcome in its continuous forms; for the categorical form of the variable, we performed a multivariable analysis using a generalized linear model to estimate the adjusted risk of inadequate or excessive gain associated with provider advice. Inadequate and excessive gains were modeled separately, with adequate gain as the referent variable in each model. Intercooled STATA 9.0 was employed for all statistical analyses.

Results

Population characteristics

Table 3.1 provides descriptive characteristics of the study population. The majority of the population was white and married, between the ages of 25 and 34, with a middle to upper socio-economic status and a greater than high school education. About 10% smoked in the first six months of pregnancy. About half of the women had a history of dieting and nearly all had a positive attitude toward pregnancy weight gain.

Less than a quarter of the population gained weight within IOM recommendations, while 10% gained less than and two-thirds gained more than recommended. When asked at 27-30 weeks' gestation, just over half reported that they had received advice about

pregnancy weight gain from a health care provider (51.8%). When compared to women who reported no advice, those who reported receiving advice were more often of a higher education level and income, nulliparous, to have a history of dieting, and to have a lesser amount of physical activity in the first trimester ($p<0.05$). Age, race, marital status, and pregravid BMI were not associated with provider advice (Table 3.1). There were no statistically significant differences in the study sample compared to the overall PIN population.

Adequacy of weight gain

Average total pregnancy weight gain among all women was 15.3 kg (33.8 lb), SD 6.1kg (13.5lb). Weight gain varied little when only term pregnancies were included, with a total weight gain of 15.6 kg (lb), SD 6.0 (13.2lb). The majority of the population gained in excess of the recommendations (Table 3.1). Adequate weight gain was lower with higher pre-pregnancy BMI: 48% of underweight women gained adequately, compared to only 25% of normal weight women, and 8% and 6% of overweight and obese women, respectively. Conversely, excessive weight gain tended to be higher with higher BMI: 33% of underweight women gained excessively compared to 64% of normal weight, 85% of overweight, and 75% of obese women. Less than a quarter of each pre-pregnancy BMI group gained less than the recommended amount of weight during their pregnancy.

Total Weight Gain and the Weight Gain Adequacy Ratio (observed/expected gain)

In the linear regression analysis, a change from no advice to receiving advice resulted in a 0.46 kg (1.01 lb)lower total pregnancy weight gain (adjusting for maternal race, parity, age, and restrained eating, 95% CI -1.22, 0.30) and a 0.003 lower weight gain adequacy ratio compared to women not reporting having received advice (adjusting for the confounders of maternal race, pre-pregnancy BMI, age, education level, gestational

diabetes, restrained eating, and total and recreational physical activity in the first trimester, 95% CI -0.10, 0.10). Neither result was statistically significant at the $p<0.05$ significance level. Following provider advice showed no association with either total weight gain or the adequacy ratio in the bivariate analysis.

Inadequate and Excessive Weight Gain using 1990 IOM Cutpoints

Table 3.2 displays the crude and adjusted relative risks and their respective 95% confidence intervals for both inadequate and excessive weight gain among women with no provider advice compared to women who reported receiving advice. We did not detect effect measure modification by race or pre-pregnancy BMI and thus one estimate each is reported for total weight gain, the ratio of observed/expected gain, and for inadequate and excessive gain. The crude analysis demonstrated a weak risk for inadequate gain, which became null after accounting for restrained eating and recreational activity in the second trimester. There was virtually no effect of provider advice on excessive gain, in either the crude analysis or after adjustment for confounders.

Advice and weight gain mediation

We hypothesized that the association between provider advice and pregnancy weight gain was mediated by diet and physical activity. Table 3.3 illustrates the steps undertaken to determine the presence of mediation using the Baron and Kenny criteria,(29) with the outcome of total weight gain in kilograms and the potential mediators of caloric intake, and self-reported physical activity in the first and second trimesters in their continuous forms. We also assessed mediation defining the outcome as: the weight gain adequacy ratio (observed/expected gain) and weight gain categorized as inadequate, adequate, or excessive; and the mediators as: total caloric intake in tertiles, and physical activity levels of no activity, below the median, or above the median (results not shown).

The Sobel test statistics varied according to which forms of the pregnancy weight gain and mediating variables we tested, with a total effect of the mediators ranging from -20.4 to 31.5%, none of which was statistically significant (results not shown). Thus neither diet nor physically activity proved to be mediators between provider advice and pregnancy weight gain.

Discussion

In keeping with previous studies of pregnancy weight gain,(12, 23, 31) the majority of our population (78%) gained outside IOM recommendations and most (65%) gained excessively. When interviewed at 27-30 weeks' gestation, just over half of the women in our study reported receiving advice from a health care professional about how much weight they should gain during pregnancy. This proportion is similar to results found by Olson and Strawderman(23) but lower than other studies of advice and weight gain.(12-14) In those studies, reported proportions receiving advice ranged from 60% in 1980,(13) 61% in 1988,(14) to 73% in 1993.(12) With the exception of Brawarsky et al, (31) these studies comprised mainly White women, who were more likely to report receiving advice than women of other races (though we did not find this in our population). Several of the earlier studies asked women to report solely about physician advice; given that we queried women about advice from any health care provider and that women interact with multiple providers throughout the course of a pregnancy, one would expect the proportion of those reporting advice to be higher in our sample but this was not the case.

Reported advice was significantly higher among women who were nulliparous, dieted and had relatively high education, income, and recreational physical activity levels in the second trimester, and low total activity in the first trimester. Parity showed the greatest variation: 63% of nulliparous women reported receiving advice versus 40% of women with 1 or more previous live births. Other studies also found multiparous women more likely to

report not being advised or being advised to gain less than recommendations stipulated.(12-14) This may be a reflection of women's relatively greater weight at second or more pregnancies.(32) In our sample, nulliparous women were more likely to be underweight or of normal weight compared to multiparous women, who were heavier. However, BMI was not associated with advice in the bivariate analyses and so it is unlikely that body size contributed to the differences in reported advice by parity. An alternative explanation is that providers assume a certain level of knowledge among women who have given birth previously than among first-time mothers, or that women in their first pregnancy are more proactive in seeking weight gain information than their multiparous counterparts.

In contrast to earlier studies(12-14, 31, 33), our results provide no evidence for an association between provider advice and pregnancy weight gain. It is possible that we did not detect an effect not because advice is unrelated to weight gain but because the type or quality of advice (which we were unable to collect) is critical to noting an effect. Brawarsky et al found that 'no physician advice' versus 'correct physician advice' had no effect on excessive gain, but that women who reported advice to gain above IOM recommendations were most likely to gain excessively (presumably compared to all other women in the study, although the comparison group is not clearly identified).(31)

Neither did we find a moderating effect of maternal race or pregravid BMI. We tested for moderation based on earlier research that had demonstrated differences in both target weight gain and advice about weight gain by maternal race and pregravid BMI. Black women were more likely to be advised to gain less than recommended compared to White women regardless of pregravid BMI,(13, 14) and pregravid overweight women were more likely to report target weight gains above IOM recommendations while underweight women more often reported target gains below recommendations, compared to women of normal pre-pregnancy weight.(15) We are uncertain as to why race and pregravid BMI did not moderate the association between advice and weight gain. We considered the possibility

that the differences may lie with what women are advised, and not whether they are advised. Although Taffel et al found that Black women were more likely to be advised to limit weight gain than White women, like our study, they also found similar proportions of Black and White women reported being advised about weight gain.(13) Unfortunately we did not have data on what women were advised and so cannot offer direct comparisons.

A lack of effect may also mean that women are receiving advice but not following it. Results from focus groups we conducted of 58 White, African American, and Hispanic pregnant women of varying body sizes suggest that women do not follow advice that they view as conflicting and generalized, desiring instead specific, clear, tailored advice (results not yet published). These results suggest that simply being advised to gain within a specific range is not enough to effect behavior change. At least one intervention study which provided education and support to participants provides evidence of this assertion: low-income women in the intervention group gained significantly less weight during pregnancy and retained less weight at 1-year postpartum compared to controls.(34) Importantly, the intervention focused on providers as well as participants. In spite of training and materials offered to providers, audited medical records revealed that providers used an intervention-provided weight gain grid for 69% of the normal weight women and only 50% of the overweight women.

Contrary to our hypotheses, neither dietary intake nor physical activity proved to be mediators in the causal pathway between advice and weight gain. It is possible that an effect exists but that neither the Sobel test nor the Baron and Kenny criteria were able to detect a difference as both approaches are known to be limited by low power.(35) More likely, no mediating effect was found because of the lack of main effect, as our results showed no association between advice and weight gain.

The prospective nature of this study limited recall bias and enabled us to capture women's experiences with advice while pregnant. The richness of the data also allowed us

to examine a multitude of covariates, such as diet, physical activity, restrained eating, and general health indicators of pre-existing diabetes and hypertension that are largely non-existent in other studies of advice and weight gain. As in others, our study was limited to maternal self-report of weight gain advice. We have neither provider input nor an objective record of whether advice was provided, what it was, or how it was offered (for example, a record obtained via video recording of clinician/woman interactions). In the absence of such a record, women's self-report is important; arguably, self-report is a critical record of what women remember of their experiences. However, increasing the knowledge base of the nature of provider advice may provide important clues about low adherence to guidelines and is an important area for future research.(6) Knowing what advice was offered, and if it differs from maternal report, could allow researchers to target problem areas for adjustment.

In their report, Influence of Pregnancy Weight on Maternal and Child Health, the authors note a "striking absence of evidence" that women follow the IOM pregnancy weight gain recommendations.(6) Likewise, our results do not support an association between provider advice and weight gain. Equally disturbing is the low proportion of women reporting any advice at all, only 52% of the population in our study. The collective findings of earlier studies(12-15) suggest that advice is an important influence on women's behavior and we believe that greater effort is needed to better understand the particular nature and role of provider advice in helping women achieve a healthy pregnancy weight gain.

Table 3.1 Distribution of maternal characteristics overall and by provider advice about pregnancy weight gain.

Maternal Characteristic	Total Sample (n=1454)		Provider Advice about Weight Gain				
			Received advice† (n=753)		Did not receive advice (n=701)		
	n	%	n	%	n	%	p-value
Race/Ethnicity							
Non-Hispanic Caucasian	1049	72.2	543	72.1	506	72.3	0.32
Non-Hispanic African American	273	18.8	149	19.8	124	17.7	
Other	131	9.1	61	8.1	70	10.0	
Education level*							
< High school	95	6.5	43	5.7	52	7.4	0.05
High school	182	12.5	82	10.9	100	14.3	
> High school	1177	81.0	628	83.4	549	78.3	
Income status*							
≤ 185% Federal poverty level	279	19.9	127	17.5	152	22.6	0.02
> 185% Federal poverty level	1121	80.1	601	82.6	520	77.4	
Marital status							
Single	282	19.4	149	19.8	133	19.0	0.75
Married	1122	77.2	576	76.5	546	77.9	
Separated, divorced, widowed	50	3.4	28	3.7	22	3.1	
Age							
≤18	42	2.9	22	2.9	20	2.9	0.10
19-24	253	17.4	119	15.8	134	19.1	
25-29	423	29.1	238	31.6	185	26.4	
30-34	495	34.0	260	34.5	235	33.5	
35+	241	16.6	114	15.1	127	18.1	
Parity (live births + stillbirths)*							
0 (Nulliparous)	726	49.9	456	60.6	270	38.5	0.00
1	479	32.9	193	25.6	286	40.8	
2	178	12.2	66	8.8	112	16.0	
3+	71	4.9	38	5.1	33	4.7	
Pre-pregnancy BMI							
Underweight	208	14.3	99	13.2	109	15.6	0.59
Normal weight	747	51.4	392	52.1	355	50.6	
Overweight	157	10.8	80	10.6	77	11.0	
Obese	342	23.5	182	24.2	160	22.8	
Diet History							
Weight Cycling							
Yes	495	49.7	265	49.8	230	49.5	0.91
No	502	50.4	267	50.2	235	50.5	
Dieting*							
Yes	564	52.3	318	56.0	246	48.2	0.01
No	514	47.7	250	44.0	264	51.8	
Restrained Eating							
Yes	502	50.5	279	52.5	223	48.2	0.17
No	492	49.5	252	47.5	240	51.8	
Health Conditions							
Pre-existing Hypertension							
Yes	100	6.9	55	7.3	45	6.4	0.51
No	1354	93.1	698	92.7	656	93.6	
Pre-existing Diabetes							
Yes	51	3.5	22	2.9	29	4.1	0.21
No	1403	96.5	731	97.1	672	95.9	
Pregnancy-Induced Hypertension							
Yes	367	25.2	194	25.8	173	24.7	0.63
No	1087	74.8	559	74.2	528	74.3	
Gestational Diabetes							
Yes	62	4.3	39	5.2	23	3.3	0.07
No	1392	95.7	714	94.8	678	96.7	

Pre-eclampsia/Eclampsia							
Yes	75	5.2	37	4.9	36	5.4	0.66
No	1379	94.8	716	95.1	663	94.6	
Smoked first 6 months of pregnancy							
Yes	164	11.3	75	10.0	89	12.7	0.11
No	1287	88.7	675	90.0	612	87.3	
Attitude toward pregnancy weight gain							
Positive	1081	93.6	572	93.5	509	93.7	0.85
Negative	74	6.4	40	6.5	34	6.3	
Received weight gain advice							
Yes	753	51.8	--	--	--	--	--
No	701	48.2	--	--	--	--	
Source of advice							
Doctor	548	74.7	--	--	--	--	--
Nurse	57	7.8	--	--	--	--	
Other health professional	129	17.6					
Followed weight gain advice							
Yes	675	91.2	--	--	--	--	--
No	65	8.8	--	--	--	--	
Advised to change physical activity during pregnancy*							
Yes	339	23.3	189	25.1	150	21.4	0.15
No	1114	76.7	563	74.9	551	78.6	
Adequacy of weight gain							
Adequate	320	22.0	167	22.2	153	21.8	0.5
Inadequate	196	13.5	109	14.5	87	12.4	
Excessive	938	64.5	477	63.4	461	65.8	
	n=1,432		n=744		n=688		
First Trimester Physical Activity	Median (IQ†		Median (IQ range)		Median (IQ		
Total activity hours in last week	range)		4.8 (2.5, 8.4)		range)		1.0
Total recreation hours in last week*	4.8 (2.2, 9.3)		1.3 (0.0, 3.0)		4.7 (2.0, 10.6)		0.02
	1.0 (0.0, 2.6)				1.0 (0.0, 2.3)		
Second Trimester Physical Activity			n=735				
Total activity hours in last week	n=1,413		4.2 (1.9 , 8.5)		n=678		0.9
Total recreation hours in last week	4.2 (1.9, 8.4)		1.0 (0.0, 2.8)		4.2 (2.0, 8.4)		0.1
	0.9 (0.0, 2.3)				0.7 (0.0, 2.0)		

*Significant differences between those who reported advice and those who did not (chi2 test of overall distribution $p<0.05$ for categorical variables; two-sided t-test of sample means for continuous variables $p<0.05$)
†Interquartile Range
Missings uniformly excluded; percents may not add due to rounding.

Table 3.2 Relative risk of inadequate or excessive gain associated with reported provider advice.

Weight Gain	Crude		Adjusted	
	Relative Risk	(95% CI)	Relative Risk	95% CI
Adequate	Referent		Referent	
Inadequate[†]	1.09	(0.87, 1.36)	0.97	0.75, 1.27
Excessive[‡]	0.99	(0.92, 1.05)	1.01	0.97, 1.06

[†]Adjusted for restrained eating and recreational activity in the 2nd trimester.
[‡]Adjusted for maternal race and pregravid BMI.

Table 3.3 Assessment of total caloric intake and total physical activity hours in the first trimester and second trimesters as potential mediators between provider advice and pregnancy weight gain, using the Baron and Kenny criteria.

Criterion	Independent Variable (mediation model)	Dependent Variable (mediation model)	Model Results	
			Coefficient	p=value
1. Independent variable is associated with dependent variable	Advice about weight gain	Total weight gain	-0.14	0.67
2. Independent variable is associated with mediating variable	Advice about weight gain	Total caloric intake	4.82	0.92
	Advice about weight gain	Total physical activity, 1st trimester	-1.40	0.02
	Advice about weight gain	Total physical activity, 2nd trimester	-0.56	0.20
3. The mediating variable is associated with the dependent variable	Total caloric intake	Actual weight gain	0.0004	0.05
	Total physical activity, 1st trimester	Actual weight gain	-0.008	0.58
	Total physical activity, 2nd trimester	Actual weight gain	-0.009	0.63
4. The association between the independent and dependent variables is attenuated when controlling for the mediating variable	Advice about weight gain	Actual weight gain[1]	-0.11	0.75
	Advice about weight gain	Actual weight gain[2]	-0.22	0.49
	Advice about weight gain	Actual weight gain[3]	-0.09	0.78

[1]Controlling for total caloric intake.
[2]Controlling for total perceived physical activity, 1st trimester.
[3]Controlling for total perceived physical activity, 2nd trimester.

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CHAPTER 4

PROVIDER ADVICE ABOUT WEIGHT LOSS AND PHYSICAL ACTIVITY IN THE POSTPARTUM PERIOD

Introduction

Weight loss postpartum

Postpartum weight retention may be an important contributor to the epidemic levels of overweight and obesity among reproductive-aged women.(1-5) Weight retention is defined as the difference between a woman's postpartum and pre-pregnancy weight.(6) Though average weight retention at 1 year postpartum is minimal, the range of weight retention is highly variable and some groups of women retain an excessive amount of pregnancy weight.(7) Gunderson et al reported mean ranges of weight retention from an index pregnancy to a subsequent pregnancy of -3.5-10.0 kg (-7.7-22.0 lbs) for the lowest quartile of weight gain to 3.0-22.0 kg (6.6 – 48.5 lbs) for the highest quartile.(8) A study of 1,423 women found average weight retention at 1 year follow-up was only 0.5 kg (1.1 lb), but ranged widely, from -12.0 to 26.0 kg (-26.5-57.3 lbs).(3) Further, fourteen percent of the study population had retained >5.0 kg (11 lbs). Olson et al followed 540 women through 1 year postpartum and found that 25% retained 4.55 kg (10.0 lbs) or greater.(9) Such findings suggest that a sizeable proportion of postpartum women are at risk for excessive postpartum weight retention.

Excessive pregnancy weight gain is the primary predictor of postpartum weight retention.(10-14) Research suggests that at some point gestational weight gain ceases to benefit the fetus and instead poses health risks for the mother.(10, 13) A study by Lawrence

et al found that women who gained more fat mass did not give birth to heavier babies but rather retained that weight as maternal fat stores.(15) Similarly, a study by Scholl et al found that an excessive rate of weight gain by women within a normal Body Mass Index (BMI) range did not promote infant outcomes but rather increased overweight status among women after birth.(12) The effects of excessive weight gain on postpartum weight retention have been documented as far as one year after birth,(13) and some research has shown different patterns of weight retention according to race.(10) For example, White women who gained more than the recommended amount substantially increased their chances of retaining nine or more pounds compared with those who gained less; Black women with excessive gains were even more likely to retain that weight than White women in corresponding weight for height ranges.(10) Other postulated influences on postpartum weight retention include low socioeconomic status, higher parity, and high pre-pregnancy BMI.(14)

Physical activity postpartum

The 2002 American College of Obstetricians and Gynecologists (ACOG) guidelines for exercise during pregnancy and the postpartum period advise that postpartum women should resume regular activity gradually as medically advised.(16) ACOG addresses the safety of exercising while nursing and the benefit of exercise in reducing the risk of postpartum depression, but does not mention the role of physical activity in weight loss. Evidence suggests that over half of the adult female population does not meet physical activity recommendations put forth by the Centers for Disease Control (CDC) and the American College of Sports Medicine (ACSM).(17) Specific data on postpartum women's activity levels are non-existent.

Studies of the benefits of physical activity for postpartum weight loss have yielded inconclusive results. Several studies found that physical activity postpartum aids women in

returning to their pre-pregnancy weight and reducing overall weight retention.(18-22) For example, the Stockholm Pregnancy and Weight Development Study followed 1,432 women from pregnancy through one year postpartum and found that women who engaged in regular recreational physical activity were more likely to return to their pre-pregnancy weight than women who exercised less often or not at all.(22) In contrast, other studies did not demonstrate such an association.(23-25)

Determinants of physical activity in the postpartum period are not well studied. Working greater than 45 hours/week during pregnancy, already having a child in the home, and reporting that lack of childcare was a barrier to activity were all found to predict low physical activity postpartum.(26) Other studies found high self efficacy(27, 28) and being in the action and maintenance stages of change(28) [based on the Stages of Change theory(29)] predicted high activity postpartum. Another study found high levels of activity among women who participated in physical activities they had defined as “fun”, including exercising socially and engaging in hobbies.(20)

Provider advice about weight loss and physical activity postpartum

Although health care providers are potentially important sources of information about healthy weight loss and physical activity in the postpartum period, we were unable to locate published observational studies that examined the role of provider advice on postpartum weight retention or physical activity. Evidence from other areas of study suggests that many patients do follow the advice they receive from their providers, whether that advice is to get a mammogram, lose weight, or increase physical activity.(30-32) Similarly, pregnant women who reported being advised about the appropriate amount of weight to gain during pregnancy were more likely to gain within the recommended range than women not reporting such advice.(33-35)

Intervention studies that have included individualized diet and physical activity counseling to address postpartum weight loss have shown promise in reducing weight retention.(36-38) One intervention found no difference in average weight retention at 10 months postpartum, but did find that a higher proportion of the intervention group had returned to their pre-pregnancy weight compared to the control group.(38) Another reported that the intervention group was more likely to lose weight overall and to lose a greater percentage of their retained postpartum weight at 1 year postpartum than study controls.(36) Neither intervention demonstrated a change in physical activity levels as measured by questionnaire. Interpretation requires caution due to low numbers of study participants.(14)

Study aim

The purpose of this study was to determine if provider advice, as delivered routinely in early postpartum, was associated with postpartum weight loss and physical activity. Specifically, we aimed to explore the association between postpartum provider advice about weight loss and physical activity as reported by postpartum women with weight retention and physical activity levels at 3 months postpartum.

Methods

Study design and sample

Data for this study come from the Pregnancy, Infection and Nutrition Postpartum Study (PINPost), a longitudinal cohort study aimed at investigating factors related to weight loss in the postpartum period. PINPost followed women from pregnancy through 1 year postpartum. The PINPost sample is derived from 2,006 women recruited into the Pregnancy, Infection and Nutrition (PIN) study between January 2001 and June 2005. PIN is a longitudinal study of factors related to preterm birth. PIN staff recruited women from prenatal care clinics at their second prenatal visit. Eligible women were English-speaking women less

than or equal to 20 weeks' gestation who were at least 16 years old, had a singleton fetus, planned to continue care at the clinic, and had access to a telephone for interviews. Data on socio-demographics, medical history, current pregnancy, and health behaviors were collected via clinic visits, in-depth phone interviews, and self-administered questionnaires. The Institutional Review Board of the University of North Carolina at Chapel Hill approved all study protocols. Details on the PIN study can be found at http://www.cpc.unc.edu/projects/pin.

Women eligible for PINPost included those enrolled in PIN who delivered live-born infants between October 2002 and December 2005 and who lived in the study's catchment area, a 2 hour drive from UNC Hospitals (required to conduct home visits). Of the 2,006 PIN women, 462 (23%) delivered before PINPost recruitment began and 330 (16%) were ineligible for various reasons (dropping out of the study, medical complications, and multiples). Forty-five women (2%) lived outside the catchment area. Thus the final sample size of women who were eligible for PINPost was n=1,169. PINPost eligible women were approached while still pregnant and asked if they would agree to being contacted postpartum about another research study. One hundred and eighty-seven women (16%) declined participation, 285 (25%) were unreachable, and 8 (0.7%) were ineligible due to medical constraints. The remaining 688 (58.9%) agreed to participate and completed a three-month interview in their home.

PINPost staff visited study participants in their homes at three months postpartum between April, 2003 and March, 2006. Visits lasted approximately 60-90 minutes and included measurement of women's height using a standing height rod; measurement of weight and percent body fat using a Tanita bioelectric impedance scale validated for use in an adult population;(39) an extensive interview covering socio-demographics, diet, physical activity, infant feeding, body image, health behaviors, psychosocial factors, and provider

advice; and a food frequency questionnaire that assessed dietary intake in the three months prior to the home visit.

Exposure measurement – Postpartum advice about weight loss and physical activity

At the 3-month postpartum home visit, interviewers recorded maternal self-reports of postpartum provider advice about weight loss and physical activity. Participants responded to a total of 8 questions: 4 about weight loss advice and 4 about physical activity advice. For both weight loss and physical activity, they were asked: 1) At any time since delivery has a doctor or a nurse, or other health professional, or have family members or friends, given you advice about weight loss/physical activity or exercise after pregnancy? (yes/no); 2) Who gave you the advice? (select all that apply: doctor, nurse, other health professional [specify], nutritionist, midwife, internet, family member, friend); 3) What advice did they give you? [recorded verbatim]; and 4) Did you follow the advice that was given to you? (yes/no/other, specify).

Women reported advice from multiple sources, including provider and non-provider. Among women who reported receiving advice, we first combined the sources of advice into categories as follows: internet, family member, and friend were combined into one variable of 'non-provider advice'; the remaining health care related sources were grouped into 'provider advice'. We then dichotomized advice into two yes/no variables: received advice from any source (yes/no) and received advice from a health care provider (yes/no). To explore the effect of following provider advice, we created a three-level 'followed provider advice' variable as follows: received provider advice and followed it, received provider advice and did not follow it, and did not receive provider advice.

Interviewers recorded women's verbatim responses to the open-ended question, "What advice did they give you?" We grouped the responses into mutually exclusive categories and reviewed the categories for clarity and content validity. Two researchers then

independently coded each response and negotiated any coding discrepancies, editing categories as necessary until a final group of response categories was developed. The number of responses per category was summed to get an overall number of women reporting advice in a given category.

Outcome measurement – Postpartum weight retention

We calculated postpartum weight retention as the difference between body weight at three months postpartum as measured at the home visit by PINPost staff and pregravid weight ascertained by maternal self-report at the first prenatal visit. Pregravid weights were checked for biological plausibility and compared to the weight recorded at the first prenatal visit. Large discrepancies were independently evaluated for reasonableness in light of gestational age at first prenatal visit. Unreasonable weights were replaced by imputed weights using a formula based on expected weight gain for a given gestational age [as determined from date of last menstrual period (LMP) or first trimester ultrasound], n=25 (3.8%). We generated two outcome variables for postpartum weight retention: a continuous variable in kg, and as a three-level categorical variable of 0-5 lbs, 5.1-10 lbs, and >10 lbs retention (0-2.2 kg, 2.3-4.5 kg, and >4.5 kg, respectively).

Outcome measurement – Physical activity

Participants completed a physical activity questionnaire at the three-month postpartum home visit. The questionnaire included questions about moderate and vigorous physical activity (defined as at least some increase in breathing and heart rate) in the areas of work, childcare, transportation, household work, and recreation. Women were asked to recall their activities in the seven days prior to the interview. For this analysis, we scored the questionnaire based on self-report of perceived intensity, whereby participants rated their activities that caused at least some increase in heart rate as fairly light, somewhat hard, or

hard/very hard. The length of time and frequency of participation in each activity were multiplied and summed for the week for each of the three intensity levels. Total activity was calculated by adding up the time per week spent in fairly light, somewhat hard, and hard/very hard activities for all activities. The questionnaire was evaluated for test-retest reliability in a sample of 109 women, with a high intra-class correlation coefficients of 0.84, 95% CI 0.77-0.89.

We created physical activity measures separately for total and recreational physical activity levels. 'Total activity' included work, transportation, childcare, and household work; 'recreation' included only recreational activities. We examined activity in its continuous form of self-reported hours/week spent in fairly light, somewhat hard, and hard/very hard (based on a woman's perceived intensity.

For total physical activity, we also divided the continuous outcome into tertiles of low, medium, and high, using low as the referent category. Tertiles allowed us to examine the outcome in a categorical form while still retaining evidence of a trend similar to the variable in its continuous form.

We also created a categorical outcome variable for recreational activity. Two-hundred and nine participants (32.1%) reported no recreational activity. Because those reporting no activity represented a sizeable and distinct group, we grouped them together and divided the remaining population at the median, separating subjects at or below the median from those above the median. Thus the three categories for recreational activity were: no activity, activity at or below the median, and activity above the median. Those with no activity were coded as the referent category. In addition, we dichotomized total physical activity in terms of having met either the Centers for Disease Control/American College of Sports Medicine (CDC/ACSM) recommendations for moderate activity or the ACSM recommendations for vigorous activity, creating the outcome of "met recommendations, yes or no".

Selected covariates

Covariates included potential effect measure modifiers and confounders identified a priori from the literature.(33-35) Potential effect measure modifiers included self-reported importance of losing weight (not important/somewhat important, important/very important), pre-pregnancy body mass index (BMI) (underweight/normal weight, overweight/obese), parity (nulliparous, multiparous), adequacy of pregnancy weight gain (inadequate, adequate, or excessive), and race (African American, Caucasian). Race was used in the analysis as a sociological construct and not a genetic factor.

Potential confounders included socio-demographic characteristics that showed statistical association ($p<0.2$) with weight loss advice or physical activity advice in the bivariate analyses. These included the potential effect measure modifiers as well as the following characteristics as self-reported by participants at the 3-month postpartum home visit: education (grade level completed), marital status (single, married, widowed, divorced), and the dichotomous yes/no variables of working outside the home, paid childcare help, depression, depression medication, and participation in an organized weight loss program.

Adequacy of gestational weight gain was defined as gaining within predetermined ranges of the 1990 Institute of Medicine (IOM) guidelines.(6) To determine weight gain adequacy, we calculated the expected weight gain for a specific gestational age and pregravid BMI status.(40) After delivery, gestational weights at each prenatal visit were abstracted from the medical chart and used to determine total gestational weight gain from beginning to end of pregnancy. Self-reported pregravid weight and height measurements were collected at the time of recruitment and used to calculate pregravid BMI after being evaluated for biological plausibility. Women were categorized into BMI categories based on the 1990 IOM cut points: BMI <19.8 kg/m2 (underweight); BMI 19.8-26.0 kg/m2 (normal weight); BMI 26.1-29.0 kg/m2 (overweight); BMI >29.0 kg/m2 (obese).(6) Adequacy was

defined based on predetermined ranges specific to pregravid BMI and expressed as the ratio of observed weight gain/expected weight gain.(41, 42)

Analysis

Twenty-one of the live births (3.1%) represented siblings born to the same mother. To remove issues of dependency, we dropped the second live birth, resulting in a final sample size of n=667 women. For the weight loss advice analyses, we limited the sample to women with weight gain data, n=661 (96.1% of the original sample of 688 women); for physical activity advice, we limited the sample to women with a physical activity data, n=652 (94.8% of the original sample). Chi square and t-test statistics were used to identify any differences in population characteristics by provider advice about weight loss and provider advice about physical activity.

Statistical modeling. Race, parity, pre-pregnancy BMI, adequacy of pregnancy weight gain, and importance of losing weight were tested as potential effect measure modifiers prior to assessing confounding by comparing the odds ratios for each of the outcomes for postpartum weight retention and physical activity among women who reported receiving: any advice; provider advice alone; provider advice and did follow it; and provider advice and didn't follow it. Effect measure modification was considered present if the Mantel Hanzel test for homogeneity detected a difference in odds ratios between groups ($p<0.1$). All other covariates were assessed as potential confounders using a 10% change rule; those that did not change the beta coefficient (for the linear regression models) or the relative risk (for the generalized linear models) by 10% or more were dropped from the final model.

For the weight loss analyses, we modeled the exposures of 'received any advice', 'received provider advice', and 'followed provider advice' on the two outcomes of postpartum weight retention as a continuous variable (in kg) and as the 3-level categorical variable of 0-5 lbs, 5.1-10 lbs, and >10 lbs (0-2.2 kg, 2.3-4.5 kg, and >4.5 kg, respectively). Few people

reported having received advice and not following it, resulting in small cell sizes once we stratified by the 3-level postpartum weight retention variable. To address this, we dichotomized postpartum weight retention as <=10lbs and >10lbs (<=4.5 kg, >4.5kg, respectively) and modeled the followed advice exposures on this outcome.

We modeled the physical activity exposures of received any advice, received provider advice, and followed provider advice on five physical activity outcomes: the continuous variables of total physical activity (hours/week) and total recreational activity (hours/week), as well as the categorical variables of total activity (medium activity level vs. low, high activity level vs. low), recreational activity (no recreational activity vs. medium recreational activity level, no recreational activity vs. high recreational activity level), and met CDC/ACSM recommendations for vigorous physical activity (yes vs. no).

Linear regression was used to examine the outcomes in their continuous forms. For the categorical forms of the outcome variables, we performed multivariable analyses using a generalized linear model to estimate the adjusted relative risks and 95% confidence intervals associated with each exposure-outcome relationship. Because some cell sizes for the 'followed advice' variables were small, we ran those models using exact regression; we found no real difference in estimates or confidence intervals and therefore used asymptotic methods for all models. Intercooled STATA 9.0 was employed for all statistical analyses.

Results

Population characteristics

Table 4.1 presents selected socio-demographic and behavioral characteristics of the study population, stratified by provider advice about weight loss and provider advice about physical activity. The majority of the population was white (76.4%), married (81.3%), educated beyond high school (82.5%) and had a high income (>350% of the Federal Poverty Level index, or FPL) (61.6%). One-third began pregnancy overweight or obese, two-

thirds gained excessively, and nearly half had weight retention of >10lbs at 3 months postpartum. Retention at 3 months postpartum ranged from -37.0 to 50.7 lbs (-16.8-23.0kg). Average weekly activity reported was 7.3 hours per week of total activity and 2.4 hours of recreational activity. The vast majority (82.1%) did not meet the CDC/ACSM recommendations for physical activity.

Advice

Most of the population reported receiving no weight loss advice (76.2%) and no physical activity advice (63.7%) (Fig. 4.1). Compared to those reporting no advice, a greater proportion of those who reported weight loss advice were African American, single, and of a heavier pregravid weight, while those reporting physical activity advice were more often nulliparous, non-smoking, and educated beyond high school ($p<0.05$).

Women were given the option of reporting more than one source of advice. Women most commonly reported advice from physician, family, and friends. It was uncommon for women to report either weight loss or physical activity advice from other sources. For weight loss advice, 84.3% (n=134) reported advice from a single source. Thirty-nine percent (n=62) reported provider only advice, 54.1% (n=86) reported non-provider only, and 6.9% (n=11) reported both provider and non-provider (data not shown). Similar proportions reported a single source of physical activity advice (83.9%, n=203), with 50.8% (n=123) reporting provider only advice, 37.6% (n=91) non-provider only, and 11.6% (n=28) both provider and non-provider (data not shown).

Most women who reported receiving provider advice also reported following the advice: 70.2% (n=94) for weight loss and 63.2% (n=139) for physical activity advice (data not shown). Nearly 70% of the women in our study indicated that losing weight postpartum was important (24.7%, n=164) or very important (43.9%, n=291).

Table 4.2 provides a summary of responses given by women who reported provider advice about either weight loss or physical activity in answer to the question, "What advice did they give you?" A total of 73 women (10.9% of the sample) reported provider weight loss advice, amounting to 103 pieces of weight loss advice; 151 women (22.6%) reported 211 pieces of physical activity advice from providers. For weight loss advice, almost a quarter reported being advised to lose weight or adjust their diet by reducing overall calories, carbohydrate, fat, or sugar intake and nearly 20% reported being told to exercise. Almost a quarter of the women reporting physical activity advice stated being encouraged to exercise and close to 20% stated permission to exercise (in contrast to encouragement). Almost 10% of women were told to "give it time" and not to worry about weight loss, while just over 5% were told to take it easy regarding exercise. Few women reported specific, detailed information either about weight loss or physical activity.

Statistical analysis– weight loss advice

After adjustment for multiple confounders, receiving advice from any source was associated with greater weight retention of 0.82 kg (1.8 lbs) at 3 months postpartum compared to no advice (p=0.04, 95% CI 0.04, 1.60) (Table 4.3). We found no association between advice from a provider and weight retention.

In the categorical analysis, we first modeled the effect of advice on weight retention of 5.1-10.0 lbs compared to ≤5.0 lbs retention. Compared to reporting no advice, neither reported advice from any source nor reported provider advice was associated with weight retention of 5.1-10 lbs (Table 4.4). When we modeled weight retention >10lbs vs. ≤5lbs, we found a differing effect by pre-pregnancy BMI (dichotomized as underweight/normal weight, or 'low BMI' vs. overweight/obese, or 'high BMI'). Among women with low pre-pregnancy BMI, reported weight loss advice from any source resulted in a 30% increased risk of a >10 lb weight retention compared to reporting no advice but showed no effect among women

with a high pre-pregnancy BMI. When compared to no advice, reported provider advice was not associated with weight retention regardless of pre-pregnancy BMI (Table 4.4).

Finally, we explored the effect of following provider advice on weight retention. Stratification by pre-pregnancy BMI and whether advice was followed resulted in small cell sizes and to address that we combined the outcome category of <5lbs with 5.1-10 lbs, to create a dichotomous outcome of ≤10 lb vs. >10lb weight retention. Compared to women with no advice, low BMI women who reportedly followed provider advice were 30% more likely to retain >10lbs of pregnancy weight at 3 months postpartum.

Statistical analysis–physical activity advice

In the linear regression analysis, reporting physical activity advice from any source was associated with 1 hour, 47 minutes greater total activity per week (p=0.02, 95% CI 0.33, 3.24) compared to reporting no advice and after adjusting for confounders (Table 4.5). Those with reported provider advice had just over 50 minutes greater total activity compared to those who reported no advice (p=0.3, 95% CI 0.90, 2.63). Those who reportedly followed advice had more total activity per week than those who reported not following advice, and both had greater activity than those reporting no advice (p-values >0.05)

With regard to recreational activity, after adjustment for confounders, women who reported following provider advice about physical activity had 45 minutes more of recreational activity/week compared to those reporting no advice (p=0.06, 95% CI -0.1, 1.6), while those who reported not following advice had 22 fewer minutes of activity (p=.6, 95% CI -1.7, 0.9). Reported advice from any source resulted in 19 minutes greater activity per week (p=0.4, 95% CI -0.4, 1.0) compared to no advice. Recreational activity was minimal for those with advice from provider only (5 minutes greater activity, p=.8, 95% CI -0.7, 0.9).

We further modeled the outcomes of total physical activity and recreational activity as categorical levels of low, medium, and high activity for total activity and no activity,

medium, and high for recreational activity. Women who reported advice from either any source or from a provider were more likely to be in the high total physical activity group, whereas reported advice showed no effect on being in the medium vs. low activity group (Table 4.6). We found no effect of advice from any source or provider advice on recreational activity. Compared to those reporting not receiving advice, women who reported following provider advice about physical activity were 1.4 times as likely to have high vs. low total activity levels (ARR=1.39, 95% CI 1.1, 1.7) and 1.5 times as likely to have high vs. no recreational activity levels (ARR=1.50, 95% CI 1.2, 1.7). No association was found between physical activity advice and meeting either the CDC/ACSM recommendations for moderate physical activity or the ACSM recommendations for vigorous activity. Compared to no advice, adjusted relative risks of meeting recommendations ranged from 1.1 (95% CI 0.7, 1.6) with any advice to 1.2 (95% CI 0.8, 1.9) for following provider advice (Table 4.7).

Discussion

This study examined the effect of reported provider advice in the postpartum period on weight loss and physical activity levels at 3 months postpartum. Our findings suggest little evidence of an association between reported weight loss advice, as provided in usual postpartum care, and weight retention at 3 months postpartum. In the bivariate analysis, overweight/obese women were more likely to report weight loss advice than their underweight/normal weight counterparts (39.9% vs. 20.0%, p=0.001) but we saw no influence of advice on weight retention.

We were able to adjust for many potential confounders beyond the usual socio-demographic variables, including such things as adequacy of pregnancy weight gain, caloric intake, and the importance of losing weight. In the adjusted analyses, we found that pre-pregnancy BMI modified the association between advice about weight loss and postpartum weight retention. Women who began pregnancy underweight or normal weight had a greater

risk of >10lbs vs. <=5lbs weight retention when they reported receiving advice compared to no advice, while pre-pregnancy overweight/obese women appeared to have decreased risk, but again this did not reach statistical significance.

The pattern for underweight/normal weight women may reflect a spurious association, such that women with high retention may be more likely to receive weight loss advice than women with lower retention precisely because they are in greater need of that advice. Although not statistically significant, there appeared to be a greater risk of weight retention among women who stated they followed provider advice compared to those stating they did not follow it. This may be due to the small numbers of women who reported not following advice, which resulted in imprecise estimates with wide confidence intervals. A larger sample would help elucidate any association between following provider advice and postpartum weight loss.

In contrast, physical activity advice suggested modest but potentially clinically relevant associations with total and recreational activity. Compared to no advice, reporting advice from any source was associated with 1 hour, 47 minutes greater total activity per week. Receiving provider advice but not following it showed consistently less physical activity than reporting advice from any source or following provider advice. In particular, high levels of physical activity were associated with advice – those stating they followed physical activity advice participated in high recreational activity 1.5 times more than those with stating no advice and had 1.4 times greater total activity.

It is possible that the higher activity levels are in response to advice. Another possible explanation is that the women with high activity postpartum had high activity levels prior to pregnancy, and these women more than others sought and followed advice about resuming their previous level of activity. Reported provider advice showed no effect on meeting either the Centers for Disease Control/American College of Sports Medicine

(CDC/ACSM) recommendations for moderate activity or the ACSM recommendations for vigorous activity. Only 17.9% of our population met those minimum recommendations.

Most of the women in our study indicated that losing weight postpartum was important (24.7%, n=164) or very important (43.9%, n=291), suggesting that provider advice about weight loss would be welcomed. In a study of women's postpartum health information concerns, the majority of women expressed a desire for more information about exercise and diet.(43) However, in our study, a disappointingly high proportion of women reported receiving no provider advice whatsoever – 89.1% reported no weight loss advice and 77.4% reported no physical activity advice. Notwithstanding the broad needs of postpartum women for health information on such things as breastfeeding, infant health, and postpartum depression, not advising women about weight loss and physical activity at the postpartum visit is a missed opportunity to potentially influence women's health beyond the postpartum period. Linné et al found that women a greater proportion of women who retained >1.5 kg (3.3 lbs) of their pregnancy weight at 6 months postpartum were overweight at the 15-year follow-up than women who had retained less.(2)

A greater proportion of women reported having received physical activity advice compared to weight loss advice in our study but we were unable to find previous studies for comparison. To our knowledge, only two other studies investigated provider advice about both physical activity and weight loss in the context of usual care, but neither reported the proportion of women receiving such advice.(36, 38) Kinnunen et al conducted an intervention to reduce postpartum weight retention among 92 women in six different health care centers in Finland.(38) The 48 women in the intervention group received intensive nutritional and physical activity counseling through repeated clinic visits from 2-10 months postpartum; participation rates in the counseling sessions was ≥90%. Controls (n=37) received usual care, reported to be approximately 4 minutes of provider advice for both diet and physical activity. The authors refer to the usual care as 'advice' rather than counseling.

At the conclusion of 10 months postpartum, there were no differences in mean weight retention but a higher proportion of the intervention group had returned to their pre-pregnancy weight (50%, n=23) compared to the control group (30%, n=26) (p=0.06). The adjusted odds of achieving pre-pregnancy weight was 3.89 (95% CI 1.16, 13.04) for the intervention group compared to controls. The authors highlight the need for larger trials to confirm their findings.

At least two additional interventions targeted postpartum weight loss and have shown promising results, though results should be interpreted with caution due to low numbers of participants.(36, 37) A study of 40 overweight, postpartum women (six weeks to six months postpartum) randomized 19 of the women to a “structured” intervention that included individualized diet and physical activity information and advice, as well as weekly meetings and food/activity diaries.(37) The 21 control women received a “self-directed” intervention comprising a one-hour long generalized session about diet and physical activity. At one year postpartum, among the 23 participants remaining, the intervention group had a weight loss of 7.3 kg (16 lbs), $p<0.01$, compared with the control women who showed no statistically significant weight loss (n=13 women vs. 10, respectively).

Leermakers et al found similar results. Ninety women who were 3-12 months postpartum and had weight retention of at least 6.8 kg (15 lbs) above their pregravid weight were randomized to receive either a 6-month correspondence intervention (n=47) or no treatment at all (the group received a brochure on diet and exercise) (n=43).(36) The behavioral intervention focused on decreasing fat and calorie intake and increasing physical activity and consisted of two group sessions, correspondence materials, and weekly or biweekly telephone contact that touched on progress and problem-solving. The treatment group was significantly older and more likely to be married than the control group, but did not differ on other baseline characteristics. Compared to controls, the intervention group lost significantly more weight and a significantly greater proportion returned to their pre-

pregnancy weight. The findings of the intervention studies suggest that intensive counseling results in postpartum weight reduction.

Interpretation of the present study results merits some caution. The study's observational nature prevents determining causation; i.e., physical activity advice cannot be said to increase high levels of activity, nor can weight loss advice be said to decrease weight retention, but rather the results suggest such associations. However, temporality was present in the study – provider advice occurred before the assessment of weight loss and physical activity. Women who reported advice may have been those at 6-weeks postpartum who had high retention but not enough time to lose the weight by the 3-month postpartum interview. Another limitation worth noting is the measurement of advice, which is based on maternal self-report without evidence from providers or an objective evaluation of whether or how advice was provided (as could be achieved with video-taping of patient-provider interactions). The assumption is that provider advice was received at the 6-week postpartum health care visit but this is not certain. The homogeneity of the sample is an additional study limitation; the majority of the study participants were White, highly educated, and financially well-off, limiting generalizability to other populations. In contrast to other studies, this study did however include both breastfeeding and bottle-feeding mothers.

A notable study strength is the inclusion of physical activity advice in addition to weight loss advice. A Cochrane review of postpartum weight reduction concluded that both physical activity and diet were important components of weight loss.(14) Importantly, our study also benefited from a clinically measured postpartum weight as well as a detailed, extensive questionnaire assessing time spent in a wide variety of physical activities. Participants were interviewed at 3 months postpartum about their activities in the week prior to the interview, limiting recall bias. Although based on self-report, advice measurement included not only a question about whether advice was provided, but by whom, what the

advice was, and whether it was followed. Multiple questions allowed for examination of advice in a variety of ways.

The provision of advice by health care providers stems from the premise that advice influences behavior. Our findings suggest that advice alone may not be enough to help postpartum women lose pregnancy weight or increase physical activity levels. Instead, weight retention interventions lead us to believe that women, or subgroups of women, benefit more from individualized counseling and follow-up beyond the usual 6-week postpartum. Health care providers potentially play an important role in advising women about healthy physical activity and weight loss, but few studies have explored this relationship. More work is needed to better understand what influence providers exhibit and how to maximize that influence. Future studies would benefit from a larger, more heterogeneous sample; they might also assess why advice was or was not followed. A better understanding of provider advice about postpartum weight loss and physical activity would ideally assist providers in making advice relevant and effective, with the ultimate goal of helping postpartum women be physically active and achieve a healthy weight.

Table 4.1 Distribution of maternal characteristics at 3 months postpartum, overall and by provider advice about postpartum weight loss and physical activity.

Maternal Characteristic	Total Sample (n=667)		Provider Advice about Weight Loss				Provider Advice about Physical Activity			
			Yes[*1, 2] (n=73)		No (n=574)		Yes[*3, 4] (n=151)		No (516)	
	n	%	n	%	n	%	n	%	n	%
Race/Ethnicity										
Non-Hispanic Caucasian	509	76.4	43	58.9	466	78.6	121	80.1	388	75.3
Non-Hispanic African American	99	14.9	25	34.3	74	12.5	24	15.9	75	14.6
Other	58	8.7	5	6.9	53	8.9	6	4.0	52	10.1
Education level										
< High school	36	5.4	2	2.7	34	5.7	4	2.7	32	6.2
High school	81	12.1	14	19.2	67	11.3	12	8.0	69	13.4
> High school	550	82.5	57	78.1	493	83.0	135	89.4	415	80.4
Income status (% Federal poverty level)										
≤ 185%	120	18.6	20	28.2	100	17.4	21	14.2	99	19.9
186-350%	128	19.8	12	16.9	116	20.2	28	18.9	100	20.1
>350%	397	61.6	39	54.9	358	62.4	99	66.9	298	60.0
Marital status										
Single	111	16.6	20	27.4	91	15.3	21	13.9	90	17.4
Married	542	81.3	52	71.2	490	82.5	129	85.4	413	80.0
Separated, divorced, widowed	14	2.1	1	1.4	13	2.2	1	0.7	13	2.5
Age										
≤18	9	1.3	0	0.0	9	1.5	2	1.3	7	1.4
19-24	100	15.0	18	25.0	82	14.0	15	10.1	85	16.6
25-29	153	23.2	16	22.2	137	23.3	34	22.8	119	23.3
30-34	234	35.5	23	31.9	211	35.9	55	36.9	179	35.0
35+	164	25.0	15	20.8	149	25.3	43	28.9	121	23.7
Parity (live births + stillbirths)										
0 (Nulliparous)	333	50.3	33	45.2	300	50.9	91	61.1	242	47.2
1	221	33.4	32	43.8	189	32.1	47	31.5	174	33.9
2	75	11.3	7	9.6	68	11.5	8	5.4	67	13.1
3+	33	5.0	1	1.4	32	5.4	3	2.0	30	5.9
Preterm birth										
Yes	87	13.0	12	16.4	75	12.6	23	15.2	64	12.4
No	580	87.0	61	83.6	519	87.4	128	84.8	452	87.6
Work status since birth of baby										
Working	359	53.8	46	63.0	313	52.7	85	56.3	274	53.1
Not working	308	46.2	27	37.0	281	47.3	66	43.7	242	46.9
School status since birth of baby										
Attending school	59	8.9	9	12.3	50	8.4	16	10.6	43	8.3
Not attending school	608	91.2	64	88.7	544	91.6	135	89.4	473	91.7

Breastfeeding										
Ever breastfed										
Yes	606	90.9	142	89.3	464	91.3	224	92.6	383	89.9
No	61	9.2	17	10.7	44	8.7	18	7.4	43	10.1
Still breastfeeding										
Yes	427	70.5	99	69.7	328	70.7	163	72.8	264	69.1
No	179	29.5	43	30.3	136	29.3	61	27.2	118	30.9
Maternal health and behaviors										
Smoked since birth of baby										
Yes	81	12.1	10	13.7	71	12.0	8	5.3	73	14.2
No	586	87.9	63	86.3	523	88.1	143	94.7	443	85.9
Hypertension										
Yes	50	7.5	8	11.0	42	7.1	14	9.3	36	7.0
No	617	92.5	65	89.0	552	92.9	137	90.7	480	93.0
Diabetes										
Yes	28	4.2	3	4.1	25	4.2	7	4.6	21	4.1
No	639	95.8	70	95.9	569	95.8	144	95.4	495	95.9
Depression										
Yes	98	14.7	17	23.3	81	13.6	26	17.2	72	14.0
No	569	85.3	56	76.7	513	86.4	125	82.8	444	86.1
Depression medication										
Yes	56	57.1	13	76.5	43	53.1	18	69.2	38	52.8
No	42	42.9	4	23.5	38	46.9	8	30.8	34	47.2
Organized weight loss program										
Yes	32	5.0	7	10.3	25	4.4	7	4.9	25	5.1
No	606	95.0	61	89.7	545	95.6	136	95.1	470	95.0
Weight loss medication										
Yes	8	1.2	1	1.4	7	1.2	0	0.0	8	1.6
No	659	98.8	72	98.6	587	98.8	151	100.0	508	98.5
Child care use										
Paid childcare										
Yes	181	28.5	23	33.8	158	27.8	39	27.3	142	28.8
No	455	71.5	45	66.2	410	72.2	104	72.7	351	71.2
Help from family/friends										
Yes	448	79.7	51	87.9	397	78.8	104	81.3	344	79.3
No	114	20.3	7	12.1	107	21.2	24	18.8	90	20.7
Pre-pregnancy BMI										
Underweight	92	13.8	7	9.6	85	14.4	22	14.6	70	13.6
Normal weight	363	54.6	30	41.1	333	56.3	82	54.3	281	54.7
Overweight	77	11.6	7	9.6	70	11.8	13	8.6	64	12.5
Obese	133	20.0	29	39.7	104	17.6	34	22.5	99	19.3
Pregnancy weight gain adequacy										
Adequate	146	22.1	10	13.7	136	23.1	23	15.4	123	24.0

Inadequate	94	14.2	13	17.8	81	13.8	23	15.4	71	13.8
Excessive	422	63.8	50	68.5	372	63.2	103	69.1	319	62.2
Postpartum BMI										
Underweight	28	4.2	3	4.1	25	4.2	11	7.3	17	3.3
Normal weight	332	49.9	19	26.0	313	52.8	68	45.0	264	51.3
Overweight	105	15.8	14	19.2	91	15.4	23	15.2	82	15.9
Obese	201	30.2	37	50.7	164	27.7	49	32.5	152	29.5
Postpartum weight retention at 3 months postpartum	225	34.0	24	32.9	201	34.2	50	33.6	175	34.2
<=5lbs	133	20.1	11	15.1	122	20.8	29	19.5	104	20.3
5.1-10lbs	303	45.8	38	52.1	265	45.1	70	47.0	233	45.5
>10lbs										
Importance of returning to pre-pregnancy weight										
Not important	86	13.0	7	9.6	79	13.4	19	12.6	67	13.1
Somewhat important	122	18.4	6	8.2	116	19.7	21	13.9	101	19.7
Important	164	24.7	14	19.2	150	25.4	34	22.5	130	25.4
Very important	291	43.9	46	63.0	245	41.5	77	51.0	214	41.8
Advice from health care provider										
Weight loss advice										
Yes	73	10.9	n/a	n/a	n/a	n/a	46	30.5	27	5.2
No	594	89.1	n/a	n/a	n/a	n/a	105	69.5	489	94.8
Physical activity advice										
Yes	151	77.4	46	63.0	105	17.7	n/a	n/a	n/a	n/a
No	516	22.6	27	37.0	489	82.3	n/a	n/a	n/a	n/a
Met CDC/ACSM activity recommendations	117	17.9	16	22.2	101	17.4	31	20.8	86	17.1
Yes	535	82.1	56	77.8	479	82.6	118	79.2	417	82.9
No										
	n=652		n=158		n=494		n=239		n=413	
Physical Activity	Median (IQ† range)		Median (IQ range)		Median (IQ range)		Median (IQ range)		Median (IQ range)	
Total activity hours in last week	4.5 (2.0, 9.3)		5.7 (2.1, 11.1)		4.4 (2.0, 9.0)		4.8 (2.1, 11.9)		4.2 (1.9, 8.3)	
Recreation activity hours in last week	1.5 (0.0, 3.5)		1.3 (0.0, 3.5)		1.5 (0.0, 3.5)		1.5 (0.0, 3.5)		1.3 (0.0, 3.5)	

Daily Dietary Intake Estimates	n=567	n=61	n=506	n=132	n=435
Total calories	Mean 2087.7 SD 810.9	Mean 2108.5 SD 824.9	Mean 2085.2 SD 810.0	Mean 2184.3 SD 1022.8	Mean 2058.4 SD 733.5
Carbohydrates (g)	Mean 274.2 SD 116.2	Mean 280.1 SD 118.3	Mean 273.4 SD 116.0	Mean 288.2 SD 137.0	Mean 269.9 SD 108.9
Protein (g)	Mean 71.6 SD 30.5	Mean 71.5 SD 35.7	Mean 71.6 SD 29.9	Mean 74.6 SD 37.1	Mean 70.7 SD 28.2
Fat (g)	Mean 78.7 SD 36.0	Mean 77.7 SD 37.8	Mean 78.9 SD 35.8	Mean 82.6 SD 45.5	Mean 77.6 SD 32.5

* Chi2 test of overall distribution with received advice as the referent category; two-sided t-test of sample means for continuous variables $p<0.05$.
[†]Interquartile Range
Missings uniformly excluded; percents may not add due to rounding.

[1]Weight loss advice, statistically significant at $p\leq0.2$ for age, education level, %FPL, parity, work status, ever breastfed, currently breastfeeding, depression medication, family/friends childcare help, adequacy of pregnancy weight gain, postpartum weight retention, total physical activity (perceived intensity).

[2]Weight loss advice, statistically significant at $p<0.05$ for race, marital status, depression, physical activity advice, importance of returning to pre-pregnancy weight, organized weight loss program, pre-pregnancy BMI, and postpartum BMI.

[3]Physical activity advice, statistically significant at $p\leq0.2$ for race, depression medication, importance of returning to pre-pregnancy weight, weight loss medications, adequacy of pregnancy weight gain, postpartum BMI, total caloric intake, carbohydrate, protein, and fat intake.

[4]Physical activity advice, statistically significant at $p<0.05$ for education, parity, smoking status, weight loss advice.

Figure 4.1 Percent of participants reporting a given source of advice about weight loss and physical activity (participants selected all that applied).

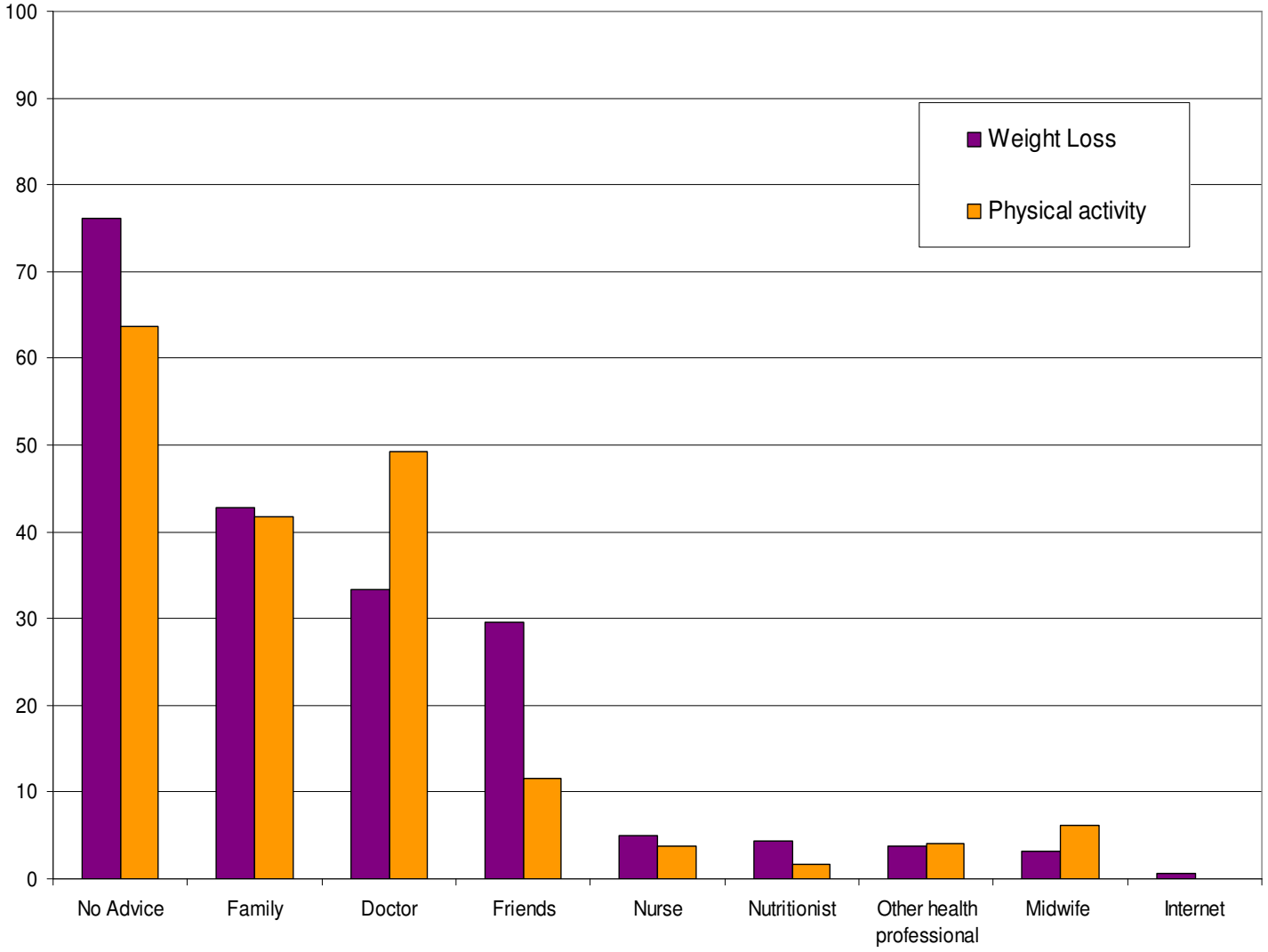

Table 4.2. Reported postpartum provider advice about weight loss and physical activity among women reporting any advice.

N	%	Weight Loss Advice	N	%	Physical Activity Advice
18	17.5	Exercise/increase exercise	50	23.7	Encouraged/advised to exercise/be active, "Exercise."
14	13.6	Lose weight	36	17.1	Given permission to resume exercise/activity, "You can exercise."
14	13.6	Eat/drink healthy	22	10.4	Given permission to resume exercise/activity at future time
10	9.7	Reduce calories/carbohydrates/fats/sweets	18	8.5	Exercise for specified number days/week, time/day
8	7.8	Breastfeed	17	8.1	Walk
8	7.8	Give it time/don't worry about weight loss	13	6.2	Take it easy/do not exercise
7	6.8	Eat less	11	5.2	Exercise/be active with some restrictions
7	6.8	Eat enough while breastfeeding	8	3.8	Lose weight/limit food intake
5	4.9	Lose the baby weight within the first 6 months/first year or it will be very hard to lose	8	3.8	Eat/drink well, do not limit food intake
4	3.9	Participate in organized weight loss program	6	2.8	Provided specific information exercising
3	2.9	Received written information to aid weight loss	5	2.4	Do conditioning exercises to specific muscle groups (including sit-ups/crunches)
1	1.0	Get social support to exercise/lose weight	4	1.9	Do a specific type of exercise
1	1.0	Do not diet/do not lose more weight	4	1.9	Exercise with children
3	2.9	Miscellaneous	9	4.3	Miscellaneous

Table 4.3 Adjusted and crude linear regression coefficients for the change in postpartum weight loss by advice about weight loss (kg).

Model	Postpartum weight retention, kg					
	Crude	p-value	95% CI	Adjusted	p-value	95% CI
Model 1.						
Advice from any source	1.04	0.03	0.11, 1.98	0.82[1]	0.04	0.04, 1.60
No advice	referent			referent		
Model 2.						
Provider advice	0.66	0.31	-0.62, 1.94	0.74[2]	0.22	-0.43, 1.91
No advice	referent			referent		
Model 3.						
Provider advice, did follow	0.81	0.27	-0.62, 2.24	0.61[3]	0.36	-0.71, 1.93
Provider advice, did not follow	0.13	0.92	-2..48, 2.75	1.23[3]	0.29	-1.07, 3.54
No advice	referent			referent		

[1]Adjusted for pre-pregnancy BMI, pregnancy weight gain adequacy, % of FPL, advice about physical activity, and importance of losing weight.
[2]Adjusted for race, marital status (married, unmarried), %FPL, pre-pregnancy BMI, adequacy of pregnancy weight gain, currently breastfeeding, family/friends help with childcare, advice about physical activity, in an organized weight loss program, and importance of losing weight.
[3]Adjusted for race, education level, marital status (married, unmarried), %FPL, pre-pregnancy BMI, adequacy of pregnancy weight gain, depression since baby's birth, use of depression medication, ever breastfed, currently breastfeeding, use of paid childcare, family/friends help with childcare, advice about physical activity, in an organized weight loss program, and importance of losing weight.

Table 4.4 Relative risks of postpartum weight retention at 3 months postpartum, by provider advice about postpartum weight loss and whether advice was followed. Note that for all models, pregravid BMI was an effect measure modifier for >10lbs of weight retention; for model 3, the outcome was dichotomized at <=10lbs v. >10lbs due to small cell sizes.

	5.1-10lbs retention				>10 lbs, Low pregravid BMI				>10 lbs, High pregravid BMI			
Model	Crude RR	(95% CI)	ARR	(95% CI)	Crude RR	(95% CI)	ARR	(95% CI)	Crude RR	(95% CI)	ARR	(95% CI)
Model 1. [a]												
Advice from any source	0.83	(0.57 1.22)	0.98[1]	(0.62,1.56)	1.46	(1.25,1.71)	1.31[2]	(1.14,1.49)	0.97	(0.72, 1.30)	n/a[3]	n/a[3]
No advice (referent)	1.0		1.0		1.0		1.0		1.0		1.0	
Model 2. [a]												
Provider advice alone	0.83	(0.50,1.38)	1.09[4]	(0.69,1.72)	1.38	(1.13, 1.69)	1.12[5]	(0.89,1.40)	0.80	(0.53, 1.22)	n/a[3]	n/a[3]
No advice (referent)	1.0		1.0		1.0		1.0		1.0		1.0	
Model 3. [b]												
Provider advice, did follow					1.28	(1.09, 1.49)	1.18[6]	(0.99,1.41)	0.91	(0.64, 1.30)	1.09	(0.74,1.60)
Provider advice, did not follow					1.05	(0.66, 1.69)	0.91[6]	(0.61,1.35)	0.55	(0.22, 1.39)	0.78	(0.38,1.60)
No advice (referent)					1.0		1.0		1.0		1.0	

ARR=Adjusted Relative Risk

[a]Referent is <=5.0 lbs weight retention.

[b]Referent is <=10.0 lbs weight retention.

[1]Adjusted for pre-pregnancy BMI and family/friends help with childcare.

[2]Adjusted for maternal education and excessive pregnancy weight gain.

[3]Adjusted estimate not applicable, no confounders identified.

[4]Adjusted for race and pre-pregnancy BMI.

[5]Adjusted for adequacy of gestational weight gain and importance of losing weight.

[6]Adjusted for adequacy of pregnancy weight gain.

[7]Adjusted for adequacy of gestational weight gain and participation in organized weight loss program.

Table 4.5. Adjusted and crude linear regression coefficients for the change in postpartum physical activity (hours/week) by advice about physical activity.

Model	Total physical activity, hrs/wk						Recreational physical activity, hrs/wk					
	Crude RR	p-value	95% CI	Adjusted RR	p-value	95% CI	Crude RR	p-value	95% CI	Adjusted RR	p-value	95% CI
Model 1.												
Advice from any source	1.67	0.01	0.34, 3.01	1.78[1]	0.02	0.33, 3.24	0.34	0.25	-0.24,0.92	0.32[4]	0.37	-0.38, 1.02
No advice	Ref.			Ref.			Ref.			Ref.		
Model 2.												
Provider advice	0.52	0.51	-1.02, 2.06	0.86[2]	0.34	-0.90, 2.63	0.14	0.67	-0.52,0.80	0.09[5]	0.82	-0.71, 0.90
No advice	Ref.			Ref.			Ref.			Ref.		
Model 3.												
Provider advice, did follow	0.98	0.27	-0.76, 2.72	1.60[3]	0.09	-0.24, 3.45	0.83	0.02	0.14, 1.52	0.76[6]	0.06	-0.05, 1.56
Provider advice, did not follow	0.04	0.97	-2.64, 2.73	0.93[3]	0.55	-2.12, 3.99	-0.62	0.26	-1.69,0.46	-0.38[6]	0.57	-1.70, 0.94
No advice	Ref.			Ref.			Ref.			Ref.		

Ref=Referent

[1]Adjusted for parity, depression medication, and caloric intake.

[2]Adjusted for race, education level, pre-pregnancy BMI, adequacy of pregnancy weight gain, smoked since baby's birth, use of depression medication, advice about weight loss, and caloric intake.

[3]Adjusted for race, education level, pre-pregnancy BMI, adequacy of pregnancy weight gain, smoked since baby's birth, use of depression medication, advice about weight loss, importance of losing weight, and caloric intake.

[4]Adjusted for education, parity, pre-pregnancy BMI, advice about weight loss, importance of losing weight, and caloric intake.

[5]Adjusted for race, education, parity, adequacy of pregnancy weight gain, smoked since baby's birth, advice about weight loss, importance of losing weight, and caloric intake.

[6]Adjusted for race, education, parity, pre-pregnancy BMI, adequacy of pregnancy weight gain smoked since baby's birth, use of depression medication, advice about weight loss, importance of losing weight, and caloric intake.

Table 4.6 Relative risks of level of total and recreational postpartum physical activity[a] at 3 months postpartum, by advice about postpartum physical activity and whether advice was followed.

	Total physical activity								Recreational physical activity							
	Medium vs. Low				High vs. Low				Medium vs. No activity				High vs. No activity			
Model	RR	(95%CI)	ARR	(95%CI)	RR	(95%CI)	ARR	(95%CI)	RR	(95%CI)	ARR	95%CI	RR	(95%CI)	ARR	(95%CI)
Model 1.																
Any advice	0.96	(0.79,1.18)	n/a[1]	n/a[1]	1.23	(1.02,1.49)	n/a[1]	n/a[1]	1.20	(1.00,1.43)	n/a[1]	n/a[1]	1.10	(0.91,1.33)	n/a[1]	n/a[1]
No advice	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Model 2.																
Provider advice alone	1.08	(0.87, 1.35)	n/a[1]	n/a[1]	1.25	(1.02, .52)	n/a[1]	n/a[1]	1.16	(0.95,1.41)	n/a[1]	n/a[1]	1.12	(0.90,1.38)	n/a[1]	n/a[1]
No advice	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	
Model 3.																
Provider advice, did follow	1.16	(0.90, 1.49)	n/a[1]	n/a[1]	1.39	(1.12,1.72)	n/a[1]	n/a[1]	1.34	(1.08,1.66)	1.21[2]	(0.95,1.54)	1.50	(1.24,1.80)	n/a[1]	n/a[1]
Provider advice, did not follow	1.05	(0.72, 1.53)	n/a[1]	n/a[1]	0.94	(0.58,1.52)	n/a[1]	n/a[1]	0.90	(0.61,1.33)	0.79[2]	(0.51,1.24)	0.37	(0.15,0.91)	n/a[1]	n/a[1]
No advice	1.0		1.0		1.0		1.0		1.0		1.0		1.0		1.0	

[a]Referent is low activity for total physical activity and no activity for recreational activity.
[1]Adjusted estimate not applicable, no confounders identified.
[2]Adjusted for importance of losing pregnancy weight and caloric intake.

Table 4.7 Relative risks of meeting CDC/ACSM recommendations[a] for moderate physical activity or ACSM vigorous physical activity at 3 months postpartum, by provider advice about physical activity and whether advice was followed.

	Met Recommendations			
Model	Crude	(95% CI)	Adjusted	(95% CI)
Model 1.				
Advice from any source	1.16	(0.83, 1.62)	n/a	n/a
No advice (referent)	1.0		1.0	
Model 2.				
Provider advice alone	1.22	(0.84, 1.76)	1.08[1]	(0.72, 1.63)
No advice (referent)	1.0		1.0	
Model 3.				
Provider advice, did follow	1.29	(0.85, 1.96)	1.19[1]	(0.76, 1.86)
Provider advice, did not follow	1.26	(0.66, 2.39)	1.10[1]	(0.52, 2.36)
No advice (referent)	1.0		1.0	

[a]Referent is did not meet recommendations.
[1]Adjusted for caloric intake.

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CHAPTER 5

CONCLUSION

Summary of Key Findings

This dissertation aimed to better understand factors associated with excessive pregnancy weight gain as well as postpartum weight retention and physical activity levels using a longitudinal cohort sample of pregnant women followed through 3 months postpartum. Specifically, we aimed to examine the association between: maternal attitudes about pregnancy weight gain and measured weight gain; provider advice about weight gain during pregnancy and measured weight gain; provider advice about physical activity and physical activity levels in early postpartum; and provider advice about weight loss and weight retention in early postpartum. Collectively, the dissertation results reflect the intransigent nature of excessive weight gain and postpartum weight retention and highlights the immense challenges associated with changing women's physical activity and weight related behaviors.

Attitudes and pregnancy weight gain

Chapter 2 examined women's attitudes toward pregnancy weight gain and whether their overall pregnancy weight gain was above, below, or within IOM recommendations. We found that most women had excessive pregnancy weight gain (64%) and that the overwhelming majority, 96%, had a positive attitude toward weight gain. Pregravid BMI was a predictor of attitude: underweight and normal weight women were more likely to have a

positive vs. a negative attitude, while the converse was true for overweight and obese women.

Our findings showed no association between a woman's attitude toward pregnancy weight gain and excessive gain (RR 1.0, 95% CI 0.9-1.1) but did find a weak association between a negative attitude and inadequate gain (RR 1.4, 95% CI 1.2-1.6), as measured by the composite score of the PWGAS. In keeping with other studies,(1-5) we did identify a handful of individual items on the scale that showed a strong association with excessive weight gain. These items included worrying about getting fat, feeling embarrassed and unattractive because of weight gain, feeling embarrassed when being weighed at prenatal visits, and being bothered by not being able to wear current fashions while pregnant.

The poor prediction of excessive gain by PWGAS' composite score is not entirely surprising given that the PWGAS was developed to predict inadequate gain in a time period, greater than 20 years ago, in which too little pregnancy weight gain was of greater concern than too much.(6) Our study results suggest that the items that predicted excessive gain might prove useful as part of an updated tool designed specifically to identify women at risk for excessive gain.

Provider advice and pregnancy weight gain

Continuing our examination of excessive pregnancy weight gain, in Chapter 3 we explored the association between provider advice about pregnancy weight gain and whether overall gain was above, below, or within IOM recommendations. Again, most women (65%) gained in excess of IOM recommendations. Just over half (51.8%) reported receiving advice from a health care professional about how much weight they should gain during pregnancy. This proportion is lower than three early studies of advice and weight gain,(7-9) in which reported proportions receiving advice ranged from 60% in 1980,(7) 61% in 1988,(8) to 73% in 1993.(9), but similar to more recent studies.(10-13)

In contrast to earlier studies, reported advice showed no association with pregravid BMI or maternal race in the bivariate analyses. Of note, first time mothers were more likely to report provider advice than their multiparous counterparts (63% vs. 40%, $p<0.05$). Other studies also found multiparous women more likely to report not being advised or being advised to gain less than recommendations stipulated.(7-9) A possible explanation is that providers assume a certain level of knowledge among women who have given birth previously and thus are not inclined to advise them, or that women in their first pregnancy are more proactive in seeking weight gain information than women who've given birth before, but our data did not allow us to explore these possibilities.

Our results provided no evidence for an association between provider advice and pregnancy weight gain, a finding in contrast to earlier studies.(7-10, 12) We considered the possibility that advice is related to weight gain but that we did not detect an effect because the type or quality of advice are important aspects of advice, data on which we were unable to collect. A lack of effect may also mean that women received advice but did not follow it. Results from prior focus groups we conducted of 58 White, African American, and Hispanic pregnant women of varying body sizes suggest that women do not follow advice that they view as conflicting and generalized, desiring instead specific, clear, tailored advice (results not yet published).

Such findings suggest that simply being advised to gain within a specific range is not enough to effect behavior change. The collective results of earlier studies indicate that advice is an important influence on women's behavior, and as such, we conclude that greater effort is needed to better understand the particular nature of provider advice about appropriate pregnancy weight gain.

Postpartum provider advice weight loss and physical activity

Turning attention to the postpartum period, Chapter 4 examined the effect of reported provider advice in the postpartum period on weight loss and physical activity levels at 3 months postpartum. Weight retention varied greatly, ranging from -37.0 to 50.7 lbs (-16.8-23.0kg). Nearly half (45.8%) of the study population had retention of >10lbs at 3 months postpartum. Average weekly activity was 7.3 hours per week of total activity and 2.4 hours of recreational activity. The vast majority (82.1%) did not meet minimum CDC/ACSM recommendations for moderate and/or vigorous physical activity levels. Very few women reported provider advice: only 11% reported weight loss advice and 23% reported physical activity advice. However, most women who reported receiving provider advice also reported following the advice: 70% for weight loss and 63% for physical activity. Nearly 70% of the women in our study indicated that losing weight in the postpartum period was important or very important to them.

In the statistical analysis of weight loss advice, we found no association between weight retention and advice from a health care provider. However, advice from any source (i.e., providers and/or non-providers) appeared to be related to retention: in the linear regression analysis, receiving advice from any source was associated with greater weight retention of 0.82 kg (1.8 lbs) at 3 months postpartum compared to no advice (p=0.04). In the categorical analysis, we found a differing effect of advice by pre-pregnancy BMI. Among women with low pre-pregnancy BMI, reported weight loss advice from any source resulted in a 30% increased risk of a >10 lb vs. <10 lb weight retention compared to reporting no advice [ARR (adjusted risk ratio) 1.31, 95% CI 1.14-1.49] but showed no effect among women with a high pre-pregnancy BMI (RR 0.97, 95% CI 0.72, 1.30, no confounders identified). While it appears that underweight and normal weight women who report any weight loss advice are at greater risk for excessive retention than women who do not report advice, we considered the possibility that this is a spurious association. It is possible that women who were

accustomed to a healthy pre-pregnancy weight and then faced with excessive weight to lose were more motivated to seek weight loss advice than either those without much weight retention or those women who began pregnancy already overweight or obese.

In contrast, physical activity advice suggested modest but potentially clinically relevant associations with total and recreational activity. Women who reported that they received provider advice and followed it showed consistently more physical activity than those who stated they did not follow the advice. Those stating they followed physical activity advice participated in higher levels of recreational activity (compared to medium and low levels) 1.5 times more than those with stating no advice (95% CI 1.15, 1.69) and had 1.4 times greater total activity (95% CI 1.12, 1.72). In spite of this, reported provider advice showed no effect on meeting either CDC/ACSM recommendations for moderate activity or the ACSM recommendations for vigorous activity.

Our findings suggest that provider advice alone, as reported by the participant, may not be enough to help postpartum women lose pregnancy weight or increase physical activity levels. Instead, weight retention interventions lead us to believe that women, or subgroups of women, benefit more from individualized counseling and follow-up beyond the usual 6-week postpartum.

Study Limitations

Interpretation of the study results merits some caution. A primary limitation is the reliance on maternal self-report for measurement of primary study variables: pregravid weight, provider advice, and physical activity. Pregravid weight, which was used to measure the outcomes of excessive weight gain and postpartum weight retention, was determined by self-report and could lead to misclassification bias if women in different BMI groups inaccurately and/or differentially report pregravid weight. Some evidence suggests that maternal self-report of weight changes through pregnancy. When asked about pregravid

weight at two points in pregnancy (20 wks and at 32 wks), 5.3% of women differed in their report by more than 1 kg.(1) More importantly, reporting appears to vary by pregravid weight status, with underweight women overestimating weight and overweight women underestimating it.(14) As a result, both underweight and overweight women may be misclassified as normal weight women. Because we grouped normal weight and underweight women together in our analyses, any misclassification bias would result from the overweight women misclassified as normal weight.

Provider advice as well was limited to women's reporting of experiences with advice. Without provider input or an objective record of whether advice was provided, what it was, or how it was offered (for example, a record obtained via video recording of clinician/woman interactions), we have no data to verify if a woman did receive advice or who gave the advice. In the absence of such a record, women's self-report is important; arguably, self-report is a critical record of what women recall of their experiences. Likewise, determination of postpartum advice was also based on maternal self-report, without evidence from providers or an objective assessment. The assumption is that provider advice was received at the 6-week postpartum health care visit but of this we cannot be certain. Incorrectly reporting whether advice was received could lead to exposure misclassification, attenuating any effects of the exposure on the outcome.

Physical activity assessment was also limited by self-report. As accurate physical activity measurements are difficult to obtain, inaccurate recall and reporting bias may exist, with heavier women reporting more physical activity than lighter women.(15) However, at least two validation studies of pregnancy physical activity questionnaires that compared self-report to the use of accelerometers found the questionnaires to be reasonable gauges of physical activity in pregnancy.(16, 17) The questionnaire used in our study was shown to have acceptable reliability and validity (results not yet published).

The homogeneity of the sample is an additional study limitation; the majority of the study participants were White, highly educated, and financially well-off, limiting generalizability to other populations. In contrast to other studies, this study did however include both breastfeeding and bottle-feeding mothers.

Study Strengths

We were fortunate to have a cohort study that followed women through pregnancy and postpartum. The prospective nature of the parent study limited recall bias and enabled us to capture women's weight gain, attitudes, weight loss, physical activity, and advice experiences while pregnant and into early postpartum. The richness of the data also allowed us to examine a multitude of covariates, including diet, physical activity, restrained eating, psychosocial measures, and general health indicators such as pre-existing diabetes and hypertension. In addition, the use of a community sample improved the likelihood of retaining participants in the study.

A notable strength of this study was the objective measurement of weight gain through pregnancy for determining gestational weight gain. Many studies are limited by reliance on self-report of total gestational weight gain and by restricting the sample to term, normal birth weight infants. In contrast, we used medical records to obtain total gestational weight gain and included low-birth weight and preterm infants, improving the study's validity and generalizability.

In our exploration of postpartum weight retention, this study included questions about physical activity advice in addition to weight loss advice. A Cochrane review of postpartum weight reduction concluded that both physical activity and diet were important components of weight loss.(18) Importantly, the study benefited from a clinically measured postpartum weight as well as a detailed, extensive questionnaire assessing time spent in a wide variety of physical activities. Participants were interviewed at 3 months postpartum about their

activities in the week prior to the interview, limiting recall bias. Although based on self-report, advice measurement included not only a question about whether advice was provided, but by whom, what the advice was, and whether it was followed. Multiple questions allowed for examination of advice in a variety of ways.

Public Health Implications

Excessive pregnancy weight gain and postpartum weight retention are contributors to the overweight/obesity epidemic in the United States. The vast proportion of American women gain much more than recommended during pregnancy and a substantial number fail to lose that weight. This dissertation contributes to the literature on provider advice to pregnant and postpartum women by furthering our understanding of the influence of advice, and factors such as attitude and physical activity, on excessive pregnancy weight gain and postpartum weight retention. Such an understanding is critical. Nearly four million women give birth every year in the United States(19) and this number is projected to rise through 2018.(20) At current rates, more than half, or two million women each year, will gain too much weight during their pregnancy,(21-23) and many will fail to lose that weight,(24) predisposing them to significant health risks.(25)

This study identified some aspects of a woman's attitude toward pregnancy weight gain that predicted excessive pregnancy weight gain, suggesting that it is possible to create a tool that will predict a woman's risk for excessive gain. Should these items be incorporated into a usable prenatal screening tool, providers might be better able to identify women at heightened risk for excessive gain and tailor their advice to a woman's particular state of mind and needs.

Unfortunately, the value of provider advice as it is recalled by women is of questionable value. In their report, Influence of Pregnancy Weight on Maternal and Child Health, the authors note a "striking absence of evidence" that women follow the IOM

pregnancy weight gain recommendations.(26) In keeping with that observation, our study results paint a dire picture of provider advice both in pregnancy and postpartum. Findings indicate that nearly half of women report no provider advice about pregnancy weight gain and advice regarding postpartum weight loss and physical activity appears to be virtually non-existent. This is in spite of the fact that 1) most women continue to gain too much pregnancy weight; 2) few meet postpartum activity levels; 3) nearly half have excessive weight retention at 3 months postpartum; and 4) the vast majority in our study indicated that losing postpartum weight is of primary importance. Importantly, advising women about weight loss and physical activity during postpartum also has the potential influence women's health beyond the postpartum period; Linné et al found that a greater proportion of women who retained >1.5 kg (3.3 lbs) of their pregnancy weight at 6 months postpartum were overweight at the 15-year follow-up than women who had retained less.(27)

Clearly there is an unmet need for improving provider advice as a potential means of reducing excessive weight gain and weight retention and increasing physical activity levels in pregnant and recently postpartum women. The collective findings of earlier studies suggest that advice is an important influence on women's behavior. Encouraging results from both pregnancy and postpartum interventions provide evidence that it is indeed possible to influence women's weight related and physical activity behaviors and, at the same time, point to the need for tailored information and intensive counseling above customary provider advice. Our results support those conclusions.

Ideally the findings herein will prove valuable both for obstetric practice and the field of women's health, by informing interventions to address excessive gain and weight retention. Increasing the proportion of women who gain an appropriate amount of weight during pregnancy, and who lose that weight postpartum, could have substantial, positive implications for women's health. This is no small feat given the pervasive and seemingly intransigent overweight and obesity crisis among reproductive-age women. The more we

understand about what might be associated with excessive pregnancy weight gain and postpartum weight retention, the better we will be able to help women achieve healthy pregnancy weight gain and appropriate postpartum weight loss.

Directions for Future Research

Much work is needed to better understand what influence, if any, providers exhibit on pregnant and postpartum women and how to maximize that influence. Health care providers presumably play an important role in advising pregnant and postpartum women about physical activity and weight related issues, but very few studies have explored these relationships. Existing research has relied on maternal self-report of advice without any input from providers themselves. Capturing the provider's side of the story is a clear priority for future research. Assessing provider practices, knowledge, skills, and self-efficacy regarding providing advice will greatly add to the literature. Future research might ask: Are providers aware of current recommendations about weight gain, weight loss, and physical activity in pregnancy and postpartum? Do they agree with the recommendations? Do they routinely advise women and do they think their advice makes a difference? Knowing what advice was offered, if it differs from maternal report and how, could allow researchers to target problem areas for adjustment.

Further, because the nature of the patient-provider relationship is complicated, and because two people often have a different account of the same interaction, an attempt to analyze actual interactions through the use of video might prove useful in illuminating what providers say, how they say it, and what women hear. A better understanding of these interactions would ideally assist providers in making advice relevant and effective.

Our study, like others, identified attitude items that were associated with excessive gain and thus showed promise in predicting who is at risk for excessive gain. Future studies could attempt to establish the temporality of attitude and excessive gain – does attitude

precede excessive gain or vice versa? Further work is needed to develop an attitude assessment tool that accurately predicts excessive pregnancy weight gain and one that ultimately may be utilized for intervention programs aimed at preventing excessive pregnancy weight gain.

Future research might also include other theoretical models, in particular the ecological model and/or the stages of change theory. The ecological model highlights the importance of factors such as family, neighborhood, and the larger community on women's health behaviors,(28) factors we weren't able to address in this study. The stages of change theory would also be useful, as it emphasizes the importance of first assessing a woman's willingness and readiness to make behavior changes before advising her to make such changes, and then tailoring advice to her particular stage of readiness.(29)

Research in both the areas of attitude and advice would benefit greatly from qualitative study which is well-suited to in-depth examination of personal experiences. Qualitative inquiry could help uncover what women feel and believe about pregnancy weight gain and why. It could provide greater insight into what women think of physical activity and weight-related issues both in pregnancy and postpartum, how they feel about the advice they receive, and why they do or do not follow it. Given the lack of studies on the provider's perspective, qualitative inquiry could prove important as exploratory research to aid in the development of a questionnaire for a large sample of providers.

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